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**SAE:** Society of Automotive Engineers, Dept. HSL, 400 Commonwealth Drive, Warrendale, Pa. 15096. **Order by title and SAE report number.**

**TRB:** Transportation Research Board, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington, D.C. 20418.



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## **ABSTRACT CITATIONS**



HS-017 947

**CONFERENCE OF THE AMERICAN ASSOCIATION  
FOR AUTOMOTIVE MEDICINE (19TH)  
PROCEEDINGS, SAN DIEGO, CALIFORNIA,  
NOVEMBER 20-22, 1975**

Papers presented to the 19th Conference of the American Association for Automotive Medicine included the following topics: safety belt and other occupant restraint systems; analyses of pedestrian, vehicle occupant, and motorcycle injuries due to traffic accidents; emergency medical services and equipment; alcohol and driving; marijuana use and driving; analysis of accident data; school bus safety improvements; and in-depth discussions of particular types of automotive crash injuries. Data from research related to the use of seat belts, three-point harness systems, air-bags, and inflatable restraint systems are discussed. A methodology for a child safety seat design is described. The design of an emergency medical unit and an emergency medical care training program are discussed. The effects of alcohol, marijuana, and carbon monoxide on driving performance are examined. Medical techniques for handling head injuries and eye injuries are described. Methods of analyzing and coding injuries resulting from traffic accidents are discussed. Injuries particular to bicycle riders, motorcycle riders, and victims of automotive crash fires are examined.

by Donald F. Huelke, ed.

American Assoc. For Automotive Medicine, 801 Green Bay Rd., Lake Bluff, Ill. 60044

1975 ; 471p refs

Includes HS-017 948--HS-017 983. Partially supported by the American Safety Belt Council, Inc., British Leland Motors, Inc., California Traffic Safety Foundation, Nissan Motor Co., Ltd., Motor Vehicle Manufacturers Assoc., A.B. Volvo Car Div.

Availability: Corporate author

HS-017 948

**MOTOR VEHICLE OCCUPANT PROTECTION--A  
HISTORICAL PERSPECTIVE**

The development of automotive occupant protective systems is traced through the life of the automobile and the usage of car safety belts is discussed. It is reported that some motor vehicles before the turn of the century came equipped with belts designed to keep passengers in their seats. Between 1900 and 1930, the emphasis was on the safe operating ability of the vehicle and occupant protection in the form of protection from the elements, one of which was not a crash. Beginning in 1931, the National Safety Council began to exhibit an awareness of the need to protect passengers involved in an accident, suggesting that the design and construction of a vehicle can materially affect the severity of accidents when they occur. Crash survivability as a science got its start just before the start of World War II in Germany and in the early 1940s in the United States with the investigation of injury prevention in the aviation field. Field studies of occupant injury in actual crashes began in Indiana in 1949, following which the Automotive Crash Injury Research Project of Cornell University became involved in refining the system used to report the data accumulated in investigations of accidents. In 1953, the Colorado State Medical Society recommended that lap-type belts be installed in all automobiles. In 1954, the American

Medical Association House of Delegates adopted a resolution calling for the same. The first technical group created to develop a standard on safety belts was established in 1955, and in 1956 the Ford Motor Company first offered a safety package which included seat belts. In 1961, Wisconsin became the first state to enact a law mandating the installation of seat belts in cars. Methods used to measure seat belt usage have included direct interviews, mail questionnaires, and direct observation, and these methods have been applied to a variety of groups within the population. The serious problems affecting the quality of information concern the nature of the groups included in the studies.

by Donald C. Lhotka

National Safety Council, Traffic Safety Dept., Chicago, Ill.

Publ: HS-017 947, Conference of the American Association for Automotive Medicine (19th) Proceedings, Lake Bluff, Ill., 1975, p1-9

1975 ; 13refs

Conference held in San Diego, Calif., 20-22 Nov 1975.

Availability: In HS-017 947

HS-017 949

**SAFETY BELT RESTRAINT SYSTEMS: COMFORT,  
CONVENIENCE, USE LAWS AS FACTORS IN  
INCREASED USAGE**

Factors affecting the use of safety belt restraint systems in automobiles are discussed. An extensive survey conducted in selected cities documented the reasons motorists don't use installed safety belts and indicated that more comfortable and convenient belt systems will increase usage and make compliance with safety belt use laws more likely. The comfort and convenience of the restraint systems in all Model Year 1974 American cars showed significant improvement over systems installed in earlier years. However, a recent study undertaken for the National Highway Traffic Safety Administration (NHTSA) concluded that a practical restraint system configuration can be designed within the present state of the art to fit 90% of the user population and be significantly favored over the 1974 system. Improvements in restraint systems, including reminder systems and starter-interlocks, have produced measurable increases in usage rates of seat belts. Future use rates can be predicted on the basis of the changes in systems and rule-making that can occur. The key to an acceptable use rate is the passage of safety belt use laws by states. Experience in other countries, including Australia, New Zealand, France, and Sweden, having seat belt use laws provides a reasonable basis for predicting use rates that would result from similar use laws in the United States. In addition, the enactment of such laws itself will quickly produce a marked improvement in comfort, convenience, and simplification of restraint systems resulting from the manufacturer's reaction to pressure for improved systems from buyers. Although 26 state legislatures have considered mandatory safety belt use laws in the past three years, none have enacted the proposed legislation. During 1975, only five States considered such legislation. New evidence exists which shows that U.S. motorists, when made aware of the potential benefits of the legislation, do favor enactment of safety belt use laws.

H. George Jossnessen; Charles H. Pulley  
Hamil Mfg. Co., Washington, Mich.; American Safety Belt  
Council, Lexington, Ky.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p1025  
1975 ; 26refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
Availability: In HS-017 947

HS-017 950

## HOW MANY NEEDED TO DIE?

All fatal accidents which occurred in the Province of Saskatchewan, Canada, during 1974 were reviewed to determine the potential benefits of universal seat belt usage. Photos of most cars in which fatalities occurred were obtained and Vehicle Deformation Indexes were assigned. Predictions for safety belt effectiveness were made using injury prediction equations developed from the Highway Safety Research Institute data bank. Of the 142 car occupants killed who had some form of restraint available, 70% would have been expected to survive if the restraints had been in use. This figure does not include 29 victims for whom no predictions could be made. Presuming the same survival rate, about another 20 persons would have survived. These figures represent 39% of all traffic accident victims in Saskatchewan in 1974. As older vehicles without the benefits of such safety features as three-point harness, improved side strength, and added rollover protection disappear from the roads, this potential benefit can be expected to increase. The survivability of accidents involving single vehicle rollovers, multi-cars, car/truck, and car/train collisions tended to reflect the different amounts of passenger compartment intrusion generally associated with each of these accident configurations. Because of the relatively low proportion of pedestrian and single vehicle/fixed object fatalities, the potential for benefits from safety belt usage may be as high or higher in Saskatchewan than anywhere else in North America.

by A. Carl Shiels; L. Glen Watson  
University of Saskatchewan, Transportation Centre,  
Saskatoon, Sask., Canada  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p26-35  
1975 ; 6refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
Availability: In HS-017 947

HS-017 951

## HOW TO FURTHER IMPROVE THE PROTECTION OF OCCUPANTS WEARING SEAT BELTS

The differences between the theoretical and the observed performances of safety belts and the factors causing injuries in observed cases were investigated by analyzing 420 accidents in Great Britain and France in which at least one occupant was injured. The occupants of the cars involved in accidents included 390 drivers and 211 passengers, of whom 276 drivers and 164 passengers were injured while wearing seat belts. The accidents included: 292 frontal impacts; 33 rear impacts; 49 lateral impacts; and 46 rollovers. The most serious injuries sustained in frontal impacts involve head, thorax, and abdomen injuries. Seat belt efficiency in frontal collisions was found to be limited by: intrusion into the car of external elements; seat belt failures; movement of the steering wheel

center; for 27% of the injured, wearing the seat belt too slackly; and overloading by the projection of the rear seat passenger. Suggested measures for reducing injuries in frontal collisions include: improving the restraint system geometry; structural reinforcement of the car; and retention of rear seat occupants. Alone or associated, these three measures would have reduced the number of most seriously injured occupants by 66%. Limitation of steering wheel movement and the provision of steering wheel padding would be sufficient to avoid most serious head injuries to drivers. Belt improvements should be designed to improve the protection of the thoracic cage. Widening the belt and providing a load limiter have shown good results in this respect. In no case was not wearing a seat belt shown to be an obvious countermeasure to injury to occupants of a car involved in an accident.

by F. Hartemann; C. Tarrere; G. M. Mackay; P. F. Gloyne; H. R. M. Hayes; D. Cesari, M. Ramet  
Association Peugeot-Renault, Lab. de Physiologie et de Biomechanique, France; University of Birmingham, Dept. of Transportation and Environmental Planning, England; O.N.S.E.R. (Lyon), Laboratoire des Chocs et de Biomechanique, France  
Publ: HS-017 947, Conference of the American Association for Automotive Medicine (19th) Proceedings, Lake Bluff, Ill., 1975, p36-48  
1975 ; 5refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
Availability: In HS-017 947

HS-017 952

## ACCIDENT EXPERIENCE IN AIR BAG-EQUIPPED CARS

The National Highway Traffic Safety Administration (NHTSA) has been collecting data on air bags or air cushion restraint systems (ACRS) for the purpose of evaluating the performance of these systems in accidents since January 1974. A summary of injury and accident severity is provided for each air-bag deployment accident that has occurred to date. However, the low volume of sales of vehicles equipped with ACRS's and a failure to report or to report accurately accidents involving the deployment of air bags have resulted in data being collected on only 69 deployment accidents. Although these data provide a valuable source of reference for future development of ACRS's, they are inadequate to allow statistical inference. The data form a valuable and illustrative counterpoint of field experience to be used in forming judgments which to date have relied mostly on laboratory experience. It is recommended that the field data be incorporated with existing laboratory data to estimate effectiveness of the systems. Such estimates must be a weighted average of the performance of the passive restraint system in various accident modes and severity levels involving varying velocity changes. A descriptive listing of all 69 accidents for which data were collected, and more detailed descriptions, including impact and injury descriptions, of the 11 accidents involving moderate or severe injury are provided.

by Russell A. Smith; Charles A. Moffatt  
National Hwy. Traffic Safety Administration, Office of Statistics and Analysis  
Publ: HS-017 947, Conference of the American Association for Automotive Medicine (19th) Proceedings, Lake Bluff, Ill., 1975, p60-79  
1975 ; 8refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
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## **INJURY ASSESSMENT OF UNEMBALMED CADAVERS USING A THREE POINT HARNESS RESTRAINT**

Nine unembalmed male cadavers, each restrained with a three point harness, were subjected to frontal force collisions at Barrier Equivalent Velocities (BEV) of 20, 30, and 40 mph in a Chevrolet Impala equipped with a modified 1974 seat belt. Injuries similar to those sustained by living humans wearing seat belts in automobile accidents, including bruises, soft tissue damage, skeletal fracture, and organ injuries, were observed. Injuries at 20 mph BEV were all rated AIS-1 consisting of bruises and a single rib fracture. At 30 mph BEV, the injuries ranged from AIS-1 to AIS-3, with the most severe injury consisting of fractures of ribs 2 through 6 on the inboard side of one cadaver. Severe injuries resulted from the 40 mph BEV exposure, with a range of AIS-3 to AIS-8. At 40 mph BEV, rib and vertebra fractures, lacerated liver, ruptured spleen, torn mesentery, bruised and torn muscles, and bowel transections were observed in the cadavers from post experimental roentgenograms and detailed autopsies. The injury severity at a given collision severity was found to be greater for the cadavers than for living humans, based on comparison with injuries from an accident investigation program. There were no fatalities in frontal force accidents at severities up to 53 mph BEV in the field study, while three out of four of the cadavers at 40 mph BEV received injuries that would have been fatal. It is concluded that the injury potential from safety harnesses can be evaluated with cadavers providing that a correction is made for the lower injury threshold of collision severity. More realistic results will be achieved as the techniques associated with cadaver experimentation are refined, including the use of simulated muscle tone and normal tissue temperature.

by R. S. Levine; L. M. Patrick  
Wayne State Univ., Detroit, Mich.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p80-92  
1975 : 25refs  
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HS-017 954

## **ARTERIAL PRESSURIZATION IN CADAVERS IN IMPACT STUDIES**

Pressurization of the cardiovascular system of cadavers during impact testing is accomplished in order to study the effects of surges in hydraulic pressure on the organs of the thorax and on the great vessels. The surges in hydraulic pressure are those that result from the decelerative forces such as might be experienced in automobile collisions. Other investigators have had problems with the pressurization of the cardiovascular system of cadavers with a normal saline solution in such tests because fluid loss from the capillaries of cadavers has been a significant problem. Southwest Research Laboratory, in San Antonio, Texas, has developed a method for minimizing the fluid loss from the capillaries when the supradiaphragmatic arterial system is to be pressurized to average diastolic pressure, 80 millimeters of mercury, by normal saline. This is accomplished by distending the supradiaphragmatic arterial system of the cadaver via a catheter introduced into the aorta with flow to the lower aorta being obturated by a distended intraaortic Miller-Abbott tube balloon placed at or near the diaphragm.

Since large increases in supradiaphragmatic mass will influence the gravity forces produced in deceleration and thus influence the injuries produced, it is important to minimize fluid accumulation in the tissues. A simple expedient to eliminate the problem of fluid accumulation in lungs, neck, head, and arms experienced in other laboratories is to introduce a 250 to 400 cubic centimeter bolus of polyethylene bead suspension into the aorta just prior to pressurization with the saline solution. The bead size varies from 4 microns to 50 microns so that when the saline for pressurization is introduced, the beads are impacted in the pre-capillary arterioles, which have an average diameter of 30 microns, and in the capillaries, with an average diameter of 8 microns, preventing passage and thus leakage of the normal saline. This method has been utilized on four cadavers to date and has been found to be completely effective in that on autopsy no edema of head, trunk, neck, or arms could be found and there was no accumulation of fluid in lung parenchyma or pleural cavity. Prior to impact, the intraaortic pressure was easily maintained at 80 to 110 millimeters of mercury with less than 1,000 cubic centimeters of normal saline solution.

by H. Haskell Ziperman; N. Herbert Peel; J. Robert Cromack  
Southwest Res. Inst., San Antonio, Tex.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p93-100  
1975 : 3refs  
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Availability: In HS-017 947

HS-017 955

## **DIVE IMPACT TESTS AND MEDICAL ASPECTS OF A 70 YEAR OLD STUNT DIVER**

The chest is a common site for serious or fatal injuries which occur in automobile accidents. In an effort to advance the knowledge of the capability of the human chest to withstand trauma, the impact response of a professional stunt diver, Henri LaMothe, was analyzed using continuous recording accelerometers and high-speed photography in a series of low level instrumented dives. The 70 year old man has for the last 27 years performed a stunt almost monthly in which he dives prone from a height of 34.5 feet into 13 inches of water. His ability to avoid injury, particularly in the thoracic region, was studied by recording the mechanical impact response of his sternum, abdomen, dorsal spine, and head during dives from a height of 5 to 15 feet. Peak accelerations in the 15 foot instrumented dives averaged 171 accelerations of gravity (g) on the sternum, 224 g on the abdomen, 25 g on the spine, and 15 g on the head. Kinematic analysis of the photographic data revealed that the unusual thoracic and abdominal tolerance necessary to withstand such high levels of prone water impact is obtained by precise body shaping before water entry and subsequent effective decelerations through rapid and progressive displacement of a large water mass. The body control allowing contact with the water surface without injury is achieved by an excellent coordination of the diaphragm, extensor musculature, spine, and flexor musculature of the hips and shoulders during the dive. Estimates of the stunt man's impact response during full-height performance dives having an impact velocity of about 46.9 feet per second give peak accelerations of 380 g on the sternum, 498 g on the abdomen, 68 g on the spine, and 41 g on the head. These predictions indicate that human tolerance to mechanical thoracic impact can exceed the commonly accepted injurious level of 60 g when the impact is expected and enough time is available for well-coordinated tensing of

muscles and shaping of the body. Medical examination of the man revealed high flexibility of his spine and hips and an unexpected level of strength and coordination of his abdominal muscles. An x-ray examination revealed marked degenerative arthritis of his spine, particularly the dorsolumbar region. Traumatic arthritis was noted in his shoulders and left wrist, but he had no disability attributable to these findings.

by David C. Viano; Richard M. Schreck; John D. States  
General Motors Res. Labs., Biomedical Science Dept.,  
Warren, Mich.; University of Rochester, School of Medicine,  
Rochester, N.Y.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p101-15  
1975; 14refs  
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HS-017 956

## A METHODOLOGY FOR CHILD SAFETY SEAT DESIGN

A systems approach, which included consideration of the anatomy and well-being of the child, a study of the driving and seating habits of the parents, and an anthropometric survey of children, was used to design a single child's safety seat which can accommodate children from 6 months to 42 months old. The design objectives for the automotive seating system for children were: protection of a child, 6 to 42 months old; compliance with all Federal standards; capability to fit all major American cars in both front and rear seats; simple installation procedure for vehicle attachment; provision of an easy method for child entry and removal; and provision of accident protection from front, side, and rear collisions. Anthropometric data were collected on children in the 6 to 42 month old range by surveying 35 children, with five children randomly selected for each of seven intervals, six months apart in age. The age range of the children for which the seating device was designed necessitated adjustability in the following restraint components: chest restraint; head rest height adjustment; and crash bar removal to accommodate older and larger children. The most realistic criteria for child safety were adopted so that the product would pass any new or foreseeable standards. Surveys of parents to determine consumer attitudes indicated that parents were concerned that the child be able to see outside in order to stay amused and that the seat provide better restraint than current products. Safety features of the resultant crashworthy, user oriented child's safety seat include the use of high density crushable materials in areas where the head, face, and shoulders would impact the seat during a crash. The restraint belts utilized to hold the child incorporated a deformable section to assist in dissipating the dynamic energy of a potential crash and thus reduce contusion and whiplash type injuries.

by Robert P. Meyer; Jack I. Laveson; Fernando J. De Castro  
Design Plus, Saint Louis, Mo. 63132; Cardinal Glennon  
Memorial Hosp., Saint Louis, Mo. 63104  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p116-23  
1975; 6refs  
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HS-017 957

## MECHANICS OF DORSAL-LUMBAR SPINE INJURY: A PRELIMINARY REPORT

Initial efforts to study whole body dynamics in simulated automobile accidents and to measure the strength of intervertebral joint components under tension are described. Automotive impact conditions were simulated using an MTS 858.01 horizontal crash simulator. Test specimens, including a fresh cadaver, car seat, and, in some cases, the dashboard, were mounted to the upper surface of the sled at an angle of 45 degrees to the direction of motion. A high speed cine record of cadaver motion was included in the study. X-rays of the dorsal-lumbar spine were taken before and after each impact. After a fracture was observed, anatomic dissection revealed the exact nature of the injury. Individual intervertebral joints were tested in tension on an MTS electro-hydraulic load frame. Twelve impact experiments were performed on two cadavers. A velocity of impact of 20 mph, with the cadaver held firmly in place with a belt across the pelvis, resulted in a fracture of the cervical area (shown on x-ray) and a tearing of the disc attachment to the end plate of the fourth lumbar vertebra (L4). An impact test conducted at 50 mph with a lap belt applied loosely above the pelvis across the lower abdomen produced a palpable separation of the spinous processes of the upper lumbar vertebrae, which included a compression fracture of L3, a separation of the posterior elements of L2 and L3, and a slight anterior displacement of L2 on L3. Anatomic dissection revealed tears of the interspinous ligaments, ligamentum flavum, and capsule of the facet joints as well as the rotator muscles of the paraspinal group. The articular facets were separated but not fractured. The cauda equina and the anterior and posterior longitudinal ligaments appeared to be intact. Two spines were obtained for tension testing. The loading pattern indicated the following sequence of failure: joint capsules, ligamentum flavum, interspinous ligament, and supraspinous ligament. The final stiffness of the specimens ranged from 663 pounds per inch to 733 pounds per inch, and the curves were only slightly concave. The failure load varied from 127 pounds to 226 pounds.

by Donald A. Nagel; Inder Perikash; Robert L. Piziali; Wilson C. Hayes  
Stanford Univ., Stanford, Calif.; Veterans Administration  
Hosp., Palo Alto, Calif.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p124-35  
1975; 22refs  
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HS-017 958

## CALIFORNIA PEDESTRIAN ACCIDENTS

Factors such as the age and sex of California pedestrian traffic accident victims, day and night involvement, pedestrian and vehicle actions prior to collision, and the influence of the socio-economic level on the age distribution of the pedestrian accidents are analyzed using data collection from 172 surveys for the year 1973. California pedestrians accounted for 861 fatalities in 1973, representing about 17% of the total traffic fatalities in the State for the year, more than the combined total of bicyclist and motorcyclist fatalities. The following conclusions were reached: the pedestrian accident problem is focussed on children under 14 years of age and senior citizens

over 65 years of age, with the senior citizen group over-represented in fatal pedestrian accidents; males accounted for 64% of the total pedestrian fatalities and 58% of the total pedestrian accidents; the majority of pedestrian injury accidents (68%) occur during the day, although 52% of the pedestrian fatalities occur at night; pedestrians are most involved in accidents when crossing or entering the roadway at an intersection and crossing or entering the roadway not at an intersection; children under 9 years of age are often involved in pedestrian accidents while playing in the roadway; the behavior of specific age groups has more influence on the distribution of pedestrian accidents than does the socio-economic level of the city; the majority of total pedestrian accidents occur while the vehicle is proceeding straight, yet a higher percentage of intersection accidents occur with the vehicle turning either right or left than in the total accident picture; and the majority of fatal and injury intersection accidents occur when the pedestrian is crossing the street at an intersection without a traffic signal.

by Janet C. Seargeant; Bruce E. Hodge  
Automobile Club of Southern California, Public Safety Dept.,  
Los Angeles, Calif.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p136-48  
1975; 10refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
Availability: In HS-017 947

HS-017 959

## PEDAL-CYCLE INJURIES

Data for bicycle injury cases were collected over a one-year period by the local chapter of the Emergency Department Nurses Association in the greater Seattle-King County area hospitals. Of the 613 cases (including three fatalities) studied, males outnumbered females two to one. The vast majority (62%) of the cases were in the 4 to 14 year old age group. People on bicycles were found to be more likely to be injured after dark than in the late afternoon. The solo accident, involving falling off the bicycle, accounted for almost 80% of the injuries. Accidents involving collision with cars accounted for only about 14% of the total injuries surveyed. Over half of the injuries were soft tissue types, about 20% were fractures, and slightly over 10% were head injuries, fractures, or concussions. About 25% of the soft tissue injuries treated in the hospitals were injuries to the head and face. Most of the head injuries occurred in solo accidents involving males. Injuries to the shoulder seem to be most peculiar to this vehicle. Instruction in safe bicycle riding and observance of the vehicle rules of the road should have an important bearing on accident rates.

by J. E. McDermott; P. A. Wood  
Emergency Dept. Nurses Assoc., Sea-King Chapter, Seattle,  
Wash.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p149-53  
1975; 5refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
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HS-017 960

## HEAD PROTECTION FOR THE BICYCLIST

The need for real head protection for the bicyclist is discussed and the specific requirements of a bicycling helmet are outlined. About one-third of all injuries to bicyclists are above the neck, 6 to 8% of which are brain concussions. An in-depth hazard analysis of bicycle accidents showed that more than 75% of all such fatalities were due to head injuries. Although a motorcycle helmet would provide more than adequate protection for the head in most bicycle accidents, a bicyclist's helmet must be light and provide adequate ventilation. Since physical exertion is the prime motive force in bicycling, heat dissipation is of utmost importance. Heat exhaustion brought about by extreme physical activity coupled with a lack of ventilation could be very hazardous. The design requirements for a bicycle helmet involve providing optimum protection and maximum ventilation in the lightest possible package. In addition, in order to be accepted by bicyclists, the helmet must be comfortable, must be a proper fit, and must be aesthetically pleasing to the eye. Bell Systems Helmets Inc. has developed a bicycle helmet constructed of Lexan polycarbonate, which has a high strength to weight ratio. The helmet includes a crushable, 0.75 inch thick, expanded polystyrene head liner and a retention system consisting of nylon webbing and a double D-ring and designed to withstand 175 pounds of pull force. This helmet was tested during the designing stages by a bicycle racing team. Impact testing consisting of allowing an instrumented head form to fall in guided free-fall from any predetermined height onto a steel anvil was conducted. The strength of the helmet retention system was measured on a hydraulic device which applies a verticle tensile load, with the helmet failing if any component of the retention system breaks before a load of 150 pounds is reached or if the strap stretches more than a specified amount under loading. The helmet's ability to withstand the injurious effects of a penetrating type of blow is determined by dropping a pointed striking object weighing 3 kilograms from a height of one meter onto the helmeted headform. The performance of the Bell helmet is satisfactory on all of these tests. Performance data for other bicycle helmets are also included.

by L. R. Lewicki; J. A. Newman  
Bell Helmets Inc., Long Beach, Calif.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p154-67  
1975; 10refs  
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HS-017 961

## HEAD INJURY EVALUATION: CRITERIA FOR ASSESSMENT OF FIELD, CLINICAL AND LABORATORY DATA

An attempt is made to provide guidelines for the comparison of field, clinical, and laboratory data on head injury. While unconsciousness, dizziness, and loss of memory play an important role in determining the Abbreviated Injury Scale (AIS) code for an actual accident victim, it is difficult to determine this kind of information from experiments on non-human primates and the information is not available at all when cadavers are used. On the other hand, information on internal brain in-

are injured fatally and autopsied. It is suggested that in assigning AIS codes to injuries to cadavers and animals during experiments, a double coding could be used to illustrate the ambiguity of the situation caused by the inability to determine such factors as loss of memory. In the case of multiple head injuries, an overall AIS number for the head can be obtained by taking the cube root of the sum of all AIS scores cubed. This method seems to provide a good correlation between multiple head injuries and an overall head AIS rating. An alphabetical list of head injuries is included, along with AIS ratings for each injury type.

by Richard L. Stalnaker; Dinesh Mohan; John W. Melvin  
University of Michigan, Hwy. Safety Res. Inst., Ann Arbor, Mich. 48105  
Publ: HS-017 947, Conference of the American Association for Automotive Medicine (19th) Proceedings, Lake Bluff, Ill., 1975, p168-78  
1975 ; 7refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
Availability: In HS-017 947

HS-017 962.

### **MONITORING HEAD INJURED PATIENTS FOLLOWING MOTOR VEHICULAR ACCIDENTS**

A new technique for monitoring intracranial pressure (ICP) and neurologic parameters in severe head injury patients has been developed by Emory University School of Medicine at Grady Memorial Hospital in Atlanta, Georgia. The monitoring technique used consists of a closed Rickham reservoir attached to an intraventricular catheter. The principal advantage of this method is that reliable measurements are obtained and the risk of infection associated with externalized ventricular cannulas is significantly reduced. However, the method does require a minor surgical procedure requiring a local anesthesia. This monitoring procedure has been used on 10 patients (seven males and three females) who sustained serious head injuries in motor vehicular accidents. Infection occurred in one patient, but was without serious consequences. Patients were continuously monitored for variable periods of time ranging from a few hours to over one week with intermittent monitoring in selected cases for up to three weeks. Of six patients who showed normal ICP during their respective monitoring periods, two had excellent results with a normal neurologic examination on follow-up, one had a good result with only mild personality alteration at the time of discharge, one had a fair result due to a persistent right oculomotor nerve palsy and moderate memory and personality defects, and two had poor results. Of the two with poor results, one was showing signs of improvement 3 months after her injury, while the other remains in a vegetable state. Four patients showed intracranial pressure ranging from moderately elevated to persistently high elevations. Of these four, one had excellent neurological recovery, two showed good results, and one died after a vegetative existence lasting 6 months. The continuous monitoring of ICP allows for rapid medical therapy directed at lowering the elevated ICP, which may favorably influence survival if such factors as the cortical damage sustained at the time of injury and the degree of herniation existent prior to the beginning of medical therapy are minimal. All of the 10 patients on whom the technique was used survived the acute phase of their injuries, and no correlation between the IC level and degree of recovery was demonstrated.

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HS-017 963

### **THE DESIGN OF AN EMERGENCY MEDICAL UNIT**

A design for a Mobile Emergency Medical Unit to provide emergency services at the scene of an accident or other disaster is discussed. Mechanical requirements of the vehicle include: that it be an all terrain vehicle; that it have a reasonable size for access to woods or fields as well as roadways; that it be powerful enough to arrive at the same time as other rescue vehicles; and that it have a levelling system (flexible range suspension) to lower or raise the vehicle when necessary. The vehicle must be composed of a driver/attendant compartment capable of holding up to three people and of serving as a rest area and office area to fill out forms and a patient compartment including two treatment areas and body extensions or openings to receive the maximum of litter patients to be protected from outside weather. The vehicle must carry such general equipment as enough water and gas tanks to give a 36 to 48 hour autonomy to the vehicle on site and rescue equipment to extricate per people from wreckage and such medical equipment as operating tables, special lighting fixtures, and a hygienic area. A chemical toilet and a cooking area will also be provided. The vehicle is to be driven to the scene of accidents and is to serve as an emergency room to treat and perform first aid to the seriously injured, to keep them alive before their transportation to the hospital in an ambulance to receive final treatment. The suggested floor plan has two openings to the patient area facing each other on opposite sides of the vehicle and can accommodate two patients on treatment tables, three patients in a waiting area, and three patients in a transfer area. Several illustrations of the proposed vehicle are included which show the floor plan and the circulation pattern.

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HS-017 964

### **A COMPREHENSIVE STATEWIDE APPROACH TO EMERGENCY MEDICAL TRAINING**

Kansas has developed a comprehensive statewide emergency medical training program which includes three levels: Basic Ambulance Attendant; Crash Injury Management for law enforcement officers; and an advanced Emergency Mobile Intensive Care training program. An instructor/coordinator training program design has been instituted which involves training the instructor/coordinators at a centralized location, the Kansas University School of Medicine, during a two to four week

training session, after which these instructor/coordinators return to their local communities to develop a liaison between the local medical community, hospitals, ambulance services, and other necessary personnel. These people are used to train the basic ambulance attendants and to lead crash injury management courses for local and state law enforcement officers. On the advanced level, 64 instructor/coordinators have been trained, of which 49 have been in the field long enough to run at least one class each. Through this approach, about 2,100 people have been trained to the Emergency Medical Technician/A level. By December 1976, all members of the State Highway Patrol will have been trained either in the Crash Injury Management program or in a refresher course. Emergency Mobile Intensive Care technicians have been trained and are staffing vehicles in Kansas City, Kansas, Johnson County, and Wichita, Kansas. Agreements with the State junior college system have been developed to provide Associate of Arts degrees in Emergency Medical Services. The entire program is run through the state medical school with a physician director, enabling the program to respond to medical rather than political needs.

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HS-017 965

#### **RELIABILITY AND VALIDITY ASSESSMENTS OF A NEWLY DEVELOPED BATTERY OF DRIVING RELATED VISION TESTS**

The usefulness of a Driver Vision Tester (DVT), developed by Henderson and Burg, as a licensing screening device was evaluated by administering the tests to 192 accident-involved drivers and 149 drivers not involved in accidents. The DVT was evaluated in terms of its reliability, practicality, and predictive validity of accident involvement. The battery of tests include: static acuity-normal illumination; central angular movement; central movement in depth; peripheral angular movement; peripheral movement in depth; tone count; static acuity - low level illumination; field of view; detection-acquisition-identification of peripheral patterns; detection-acquisition-identification of para-foveal patterns; dynamic visual acuity; static acuity with veiling glare; and static acuity with spot glare. The test results suggest that the DVT is a reliable method for measuring most of the visual functions included in the battery, since it yields consistent results with very little administrator and learning effects. Detailed examinations of the validity of the individual tests reveals that dynamic visual acuity, static acuity under low levels of illumination, and perhaps angular extent of the effective visual field differentiate between accident at-fault drivers and non-accident-involved drivers. The DVT may be significantly shortened in order to reduce the time needed to administer the test, especially since the static acuity tests and dynamic acuity tests seem to be partially independent based on a factor analysis.

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HS-017 966

#### **NEW HAZARDS IN PENETRATING WOUNDS OF THE EYE**

In order to assess the effect of phototropic spectacle and sun-glass fragments on intraocular contents, a colony of 16 New Zealand, mature male albino rabbits weighing 4 to 6 pounds were subjected to surgical procedures to insert similarly sized fragments of conventional sodium lime silicate glass, Photosun, or Photogray in the vitreous of the eyes. Each material was inserted in eight eyes. Daily observations were made and at intervals of about one week all eyes were carefully inspected by slit lamp examination, direct or indirect ophthalmoscopy, or Bronson B-scan ultrasound. Follow-up was continued for 6 months. The experiments showed a triphasic reaction consisting of a few days of post insertional inflammation followed by 7 to 14 days of relative inflammatory quietude and then progressive low grade inflammation over months. This is complicated by vitreous strands and localized hemorrhage about the fragments, particularly when they are in contact with the retina. Fragments suspended in mid vitreous evoke lesser localized reaction. It is concluded that established concepts of minimal extraction efforts for glass fragments may now need to be revised toward more prompt or heroic efforts to remove phototropic elements. The higher specific gravity of photochromic or clear crown glass fragments lead to downward migration over weeks of observation, which may be considered advantageously to bring a phototropic fragment to the inferior bulbar wall over a period of weeks or a few months. It is essential, however, to monitor cellular responses in the vitreous both by direct ophthalmoscopy and, when possible, by ultrasound examinations. Fragment opalescence or increasing reaction within the vitreous suggests early extraction.

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HS-017 967

#### **ALCOHOL IN FATAL TRACTOR TRAILER CRASHES**

Fatal accidents occurring in Maryland during 1970 through 1973 involving tractor trailers were investigated to determine whether a substantial proportion of tractor trailer drivers killed in crashes had positive blood alcohol concentrations (BAC). A total of 25 tractor trailer drivers and 63 drivers of other motor vehicles died in the 150 accidents studied. About one-third of

each group had BACs of 0.10% by weight or more. Of 17 tractor-trailer drivers apparently responsible for crashes, eight had illegal BACs. Only 2% of the surviving drivers were charged with driving while intoxicated or impaired. These results suggest that consideration should be given to the administration of chemical tests for alcohol to truck drivers at weigh stations and to all drivers, including surviving drivers, as soon as practical following all fatal accidents.

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HS-017 968

## **DRIVING AND PSYCHOSOCIAL CHARACTERISTICS OF DRUNK DRIVERS**

A self-administered questionnaire was designed to assess a number of demographic, driving, and psychosocial factors. The questionnaire was completed by 306 men arrested for drunk driving in Michigan while they were participating in mandatory rehabilitation programs following conviction; 289 alcoholic subjects; and 269 men who were offered three dollars to complete the questionnaire after they had completed license renewal procedures and who served as controls. Of the variables related to drinking, alcoholism, and drinking before driving, the drunk drivers fell between the alcoholics and the controls. However, many stress measures showed little difference between drunk drivers and controls, with both groups reporting significantly less stress than the alcoholics. The drunk drivers were more depressed than the controls, but less so than the alcoholics. They had less self-esteem and were more paranoid and aggressive than the controls, but less extreme on all three of these measures than the alcoholics. When the drunk drivers were divided into two sub-groups based on their scores on the Michigan Alcoholism Screening Test (MAST), with the 119 scoring six or more in one group and the 187 scoring less than six in the other group, there were significant differences noted between the high and low scorers. While the high scorers were more like the alcoholics than the low scorers, even the low scorers among the drunk drivers were closer to the alcoholics than to the control group on some measures. On most scales that strongly differentiated the alcoholics from the control group, including paranoid thinking, depression, and responsibility scales, the low scoring drunk drivers were significantly different from the control group. On the basis of these results, it is suggested that drunk drivers are a mixture of alcoholics and potential alcoholics, rather than a group of alcoholics and social drinkers. Between 40 and 50% of the sample of drunk drivers were alcoholics on the basis of the MAST scores.

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HS-017 969

## **CARBON MONOXIDE EFFECTS ON HIGHWAY DRIVING PERFORMANCE: AN INVESTIGATION OF THE EFFECTS OF 12 PERCENT COHB ON THE NIGHTTIME PERFORMANCE OF YOUNG AND AGED DRIVERS**

Experiments in the real highway environment were conducted to determine the effects of carboxyhemoglobin (COHb) levels on nighttime driving performance of young drivers and in comparison with the performance of aged drivers. The driving test battery consisted of freeway driving, reading highway signs, car following, driving with voluntary occlusion, curve negotiation, and estimation of time and velocity while driving. Five young healthy non-smokers and five healthy aged non-smokers (60 to 65 years old), each treated with 0% and 12% nominal COHb levels, drove an instrumented vehicle capable of recording the road scene, the point of the driver's eye fixation, elapsed time, and distance traversed on a video tape and equipped with an FM recording system which recorded steering wheel movements, vehicle velocity, lateral acceleration, and drivers heart rate. The results from the research showed that the 12% COHb level significantly affected the nighttime visual search behavior of both the young and aged subjects, but in a significantly different manner. Under the influence of 12% COHb level, the aged subjects demonstrated less peripheral sensitivity. Twelve percent COHb significantly increased the mean heart rate of the young subjects, although no change was observed for aged subjects. In general, the effects of carbon monoxide on the road were found to be much less than those found in the laboratory. The test results indicate that carbon monoxide effects are first manifested in the visual system before driver control or vehicle performance measures are affected.

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HS-017 970

## **MARIHUANA EFFECTS ON DRIVING: PERFORMANCE AND PERSONALITY**

A review of laboratory experiments investigating the effects of alcohol and marihuana on information processing and on driving-related skills is presented. There appears to be no evidence that sensory input is seriously affected at the periphery or that

performance of both concentrated and divided attention in a dose-related manner, while alcohol only impairs performance under the demands for division of attention. While both substances impair central processes, the modes of action differ. On tasks requiring sustained attention, use of marihuana caused a performance decline which continued over a one hour period, while alcohol use did not impair performance. Alcohol use slows information processing, but performance deficits resulting from marihuana intoxication have not been shown to be the result of a slowing of central processing. Memory lapses and a focussing of attention on internal events are associated with marihuana use. A shift of attention away from external events and heightened responsiveness to internal events may provide the basis for performance decrements associated with marihuana use. Comparison of data from Minnesota Multiphasic Personality Inventory (MMPI) scores of alcoholics and marihuana users show that, while alcoholics typically score high on scales which reflect deviance, depression, and anxiety, marihuana users are entirely within the boundaries for a so-called normal personality. It is concluded that on the basis of available data there is no reason to believe that marihuana use will create a greater traffic hazard than alcohol use.

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## MARIHUANA EFFECTS ON A CRITICAL TRACKING TASK

Twelve subjects were tested on a critical tracking task under placebo and active marihuana conditions. The 12 subjects were aged 21 to 32 years old and were all social users of marihuana. The subjects were trained extensively on the central tracking task and then tested before drug administration and at 15 minute intervals for 4 hours after smoking the marihuana. The mean percentage decline in performance on the task under active marihuana as compared to placebo was 8%. It is clear from these tests that marihuana has a significant effect on performance of this task. The decline in performance is sustained for 4 hours.

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HS-017 972

## THE ANALYSIS OF ACCIDENT DATA USING THE "CASE-BY-CASE MATCHING" TECHNIQUE

Some of the factors involved in the use of case-by-case matching for analyzing field traffic accident data are examined. The technique involves matching an accident with a

group of other accidents on the basis of similar vehicle and occupant factors. The injury severity of the occupant is then compared to the injury severities of the matched occupants. Case-by-case matching controls for factors by matching the factors of a given occupant in an accident involving a countermeasure-equipped vehicle with the same factors for occupants of some control or reference group of accidents where the vehicles do not have the countermeasure, such as an Air Cushion Restraint System (ACRS). For the analysis to be valid, the accidents being investigated and the control group of accidents must be a random sample from a known population, collected under similar circumstances, and coded consistently. For a factor to be important enough to be used for matching, it must be related to injury severity and be present to a different degree in the study group as compared to the control group. Failure to match all study accidents may result in a bias in the overall estimate of the effectiveness of the countermeasure being investigated. The matching technique can be implemented through computer routines or through direct analysis by a group of people. Once the accidents have been matched, the data must be summarized to estimate the overall effectiveness of the countermeasure in reducing injuries and fatalities. This may be accomplished by calculating, case-by-case, the proportion of occupants in the various injury categories for all those occupants in the control group matching a given deployment. The arithmetic average of these proportions for each study case is then calculated for a given injury level, which is compared with the distribution of injuries for all study group occupants. An analysis of the ACRS deployment data using case-by-case matching techniques showed that the ACRS reduced severe and fatal injuries by 22% in those deployment accidents matched (84% of the total ACRS deployment accidents).

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## CHAIN LINK FENCING TOP RAILS--A ROADSIDE HAZARD

Over a period of about 6 years in Dade County, Florida, in three separate motor vehicle accidents, three occupants of the involved motor vehicles lost their lives during collision with residential chain link fences. The fatal injuries received were caused by the invasion of the passenger compartment by the top rail of the chain link fence system during the off-the-road accidents. Specific injuries, injury mechanisms, vehicle factors, and environmental factors involved in each of the accidents are described. It is suggested that the problems created by a rigid fence top rail could be solved by replacing the rail with a cable. This solution would reduce the initial cost of fence materials and placement and at the same time decrease the hazard to the public. Another possible solution is the placement of chain link fencing without a top rail, perhaps using more vertical support posts. Governmental action to correct the problem of the rigid top fence rails is recommended.

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## MECHANISMS OF INJURY FROM CRASH FIRES

Mechanisms of heat transfer during crash fires and the associated physiology of burn injuries are presented as a function of exposure time, motorist location, and other related factors. The irreversible nature of severely burned skin, the extreme pain, complicated treatment requirements, and the proclivity to complications following burn injuries all combine to upgrade the priority for research needed to reduce the frequency and severity of collision-induced fire. The motorists' greatest single burn hazard is from radiation; convection exposures can be critical but generally are secondary in importance to radiation burns. Conduction burns are only occasionally encountered. Motorists burns often result directly from thermal radiation, and at times are augmented by contact with hot gasses; contact with flame or burning gasses represents an extreme combination of radiation and convective heat exposure that can cause rapid burns directly or can ignite clothing and initiate secondary burn inputs to the already overburdened skin. Gross exposure to flame for only a few seconds generally results in thermal shock. Motorists subjected to vehicular fires sustain thermal assaults generally affecting the skin; rarely are vehicular fires a serious threat to the respiratory system, except when a motorist is trapped within a confined space near a low intensity fire. It is doubtful if depressed oxygen level alone could prove fatal to a motorist trapped in a passenger compartment during a smoldering fire. The acrid fumes from combustion of plastic interior trim combined with the carbon monoxide, carbon dioxide, and heat should collectively present a life threat before critical oxygen depletion could occur. Whether thermal burns or a toxic atmosphere becomes the critical survival factor for a given accident will depend on such conditions as volume and supply of air, quality and amount of fuel, duration and rate of burn and location of generated toxic gasses. Confined passenger compartment fires can create dangerous concentrations of carbon monoxide and related toxic combustion gasses that act synergistically in combination with heat. These fires may not represent an obvious thermal threat at first and may therefore not be treated as a critical emergency by the motorist.

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HS-017 975

## THE USE OF METHYLMETHACRYLATE FOR FRONTAL BONE RECONSTRUCTION FOLLOWING VEHICLE ACCIDENTS

Victims of motor vehicle accidents sustaining bone loss or bony deformities of the forehead present special problems in their initial management as well as in subsequent reconstruction. Of the various materials currently available for reconstruction of bony frontal deformities, bone cement (methylmethacrylate) has been judged to be superior in its simplicity, reliability, and aesthetic potential. Bone cement is a composite of previously polymerized polymer granules held together by newly polymerized monomer. Tiny air spaces exist within the cement. The rigid transparent plastic can be polished smooth and is impervious to fluids, gasses, and bacteria. The bone cement is strong, has a similar density to bone, possesses a low thermal conductivity, and has an electrical conductivity similar to skull. It is very well tolerated by soft tissue, bone, and dura. None of the inadequacies and hazards associated with the use of bone cement for reconstruction of other body areas have been reported with its use in frontal reconstruction. Methods for mixing and fitting the bone cement specimen and the surgical approach to be used are described briefly.

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HS-017 976

## MEN AND WOMEN DRIVERS: A STUDY OF EXPOSURE, ACCIDENTS, AND INJURIES

The differences between the accident-involvement and injury patterns of men and women drivers were studied in relation to exposure differences. Data in current literature, Texas mass accident data, and data collected for a study of restraint system effectiveness were used. Factors considered include miles driven, day of week, time of day, type of road, driver age, accident severity, driver height, and restraint system usage. Comparisons between driving and accident distributions for each sex find men with more of their exposure in weekend, nighttime, and expressway driving and women with a larger portion in weekday, daytime, and city street driving. It is concluded that the different driving experiences tend to counteract each other to produce similar overall accident rates. Accident frequencies for both men and women peak at ages 20 through 24, but males under age 25 have a higher accident rate than women in this age group, while between the ages of 25 and 30 women have a higher rate. Accident involvement was found to vary more among age groups than it does between men and women, however. The more severe accidents tend to find more men among the drivers, but this is probably due to the exposure differences. Men and women receive and/or report different frequencies of minor injuries, but moderate, severe, and fatal injuries follow similar patterns for both sexes. Driver height was found to contribute to the injury pattern somewhat. All drivers were found to benefit from using



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HS-017 977

## HUMAN VOLUNTEER TESTING OF THE INFLATABLE BELT RESTRAINT

Dynamic sled tests of the Allied Chemical Inflataband using human volunteers and anthropometric dummies were conducted. The impact environment in which the restraint system was evaluated was representative of the deceleration characteristics of a 1972 Pinto for the frontal impact mode. The Inflataband used in the test program is an inflatable three-point harness system with lap and over the shoulder components. Inflation is provided by a pressurized gas cylinder housing two electroexplosive devices. The anthropometric test dummies (ATD) consisted of two 50th percentile male dummies, one 95th percentile dummy, and one 5th percentile female. The 12 human volunteers ranged from 20 to 28 years of age. Testing was conducted in nine stepped-severity increments starting at a total velocity change of 12.5 mph and a peak sled deceleration of 7.5 g and terminating at a total velocity change of 32.5 mph and a peak sled deceleration of 20 g. Each increment contained five dynamic sled tests, two of which were dummy tests preceding three human tests. System activation and restraining forces were accomplished with minimal expenditure of time (18 to 20 megaseconds after impact), utilizing compartment space and vehicle crush more effectively than could a conventional belted restraint system. The absence of significant trauma and the consistently low magnitude of the severity indicators demonstrated that the impact loads were effectively distributed over the chest and abdomen. The ability to control occupant head flexion and lateral displacement was shown to be dependent on the anthropometric size and the initial head position. Typical human response to impact was found to be more subdued than that of the dummy. The volunteers experienced less torso rotation about the shoulder band, less lateral displacement, and lower values of head deceleration when rebounding into the seat and head restraint below the 30 mph level. These discrepancies decrease as impact severities increase to the point of convergence above 30 mph.

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HS-017 978

## AN ANATOMICAL INJURY SCALE IN MULTIPLE TRAUMA VICTIMS

A study of 2,135 consecutive acute blunt trauma admissions over a 48 month period was conducted in an attempt to produce an objective scale for the severity of injury. All trau-

matic injuries were coded using the International Classification of Disease and Accidents (H-ICDA) prior to computer analysis. An a priori probability of survival was computed for the population under study. The patient population was divided into a training set and a test set. The training set was used to compute a conditional probability of survival (PC) for each diagnostic code, which was used to rank the injuries in order of severity. An effective probability of survival (PE) was then computed for each diagnostic code. The PE for each code was used to predict survival rates on the test set and five random groups of the patients studied and to predict the individual survival using a decision rule that a PE of greater than 0.5 resulted in survival. The 2,135 patients had injuries involving 259 different injury codes, with at least one code for each patient and the maximum number for a single patient being 14. Of these patients, 1,751 survived. Of the 1,884 random patients in the training set, 1,535 possessed at least one of the 40 diagnostic codes with a conditional probability of survival less than 1.0 (which indicates that the injury occurred at least once in a patient who died). The other 349 patients possessed at least one of 117 codes which at no time was recorded for a patient who died. These conditional probabilities were used to rank the severity of the injury codes and to provide the basis for the computation of the effective probabilities of survival. The survival rate predicted for the test set was 81%, but the actual survival rate was 86.5%. PE as derived in this study gives an objective assessment of most life-threatening injury as determined by ranking PC. The tests for internal consistency and statistical validity show that PE can be used to predict expected survival rates in the patient population to within plus or minus 4%, but that the methodology is not sufficiently refined to predict the outcome on an individual patient basis.

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HS-017 979

## RISK FACTORS IN MOTORCYCLE COLLISION INJURIES

A study was conducted to examine time trends in motorcycle crash related deaths, to examine methodologic problems in the study of motor vehicle collision death rates, and to evaluate the interrelationships between driver and vehicle factors which may contribute to the production of motorcycle injuries. Data were collected on deaths, population sizes, and registered motorcycles in the United States and in California for the period 1950 through 1974 and on motorcycle collisions in Sacramento County, California, for 1970. During this period the number of registered motorcycles in the United States and California has increased about 1,000% and 1,111% respectively. In the same period the motorcycle collision death rate more than doubled. With the exception of 1974, the average annual increase in the ratio of registered motorcycles per 100,000 population in the United States corresponded to an increase in crude death rate. A similar pattern between the use of motorcycles and crude death rates is also found in California. Stepwise discriminant analysis was used to identify interrelationships between factors associated with motorcycle collision injuries. The analysis indicated that for male drivers age was the single most significant factor related to motorcycle collision rates injuries. Other

topics included: number of prior motorcycle crashes; number of prior motorcycle driving violations; frequency of motorcycle use; motorcycle drivers' training; and height of the driver. Among drivers more than 24 years of age, the discriminating factors included age, number of prior motorcycle accidents, larger engine size of the motorcycle, use of eye protection, more frequent use of motorcycles, more experience in driving an automobile, and drivers' training.

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1975, p383-93

1975 ; 10refs

Conference held in San Diego, Calif., 20-22 Nov 1975.

Supported by a grant from the Insurance Inst. for Hwy.

Safety, Washington, D.C. and the University of California,

School of Medicine, Dept. of Community Health, Davis, Calif.

Availability: In HS-017 947

HS-017 980

## SCHOOL BUS SEAT BACK PADS--THE CALIFORNIA EXPERIENCE

A detailed questionnaire was distributed to 438 California school bus operators to obtain data to evaluate the effect of the new seat back pads used on the school busses in terms of pupil injuries and pad damage in terms of pupil exposure. In addition, a demonstration project was conducted to determine the feasibility and effects of retrofitting the pads to school busses currently in use. This activity consisted of retrofitting 16 busses in Southern California with the pads and monitoring pupil injuries, pad damage, and pupil exposure for a period of one year. Results of the initial survey indicated that the bus operators estimated that the presence of the pad prevented about 85% of potential injuries. (Of the 146 passengers on school busses involved in accidents, only 25 were injured.) The data from both the questionnaire and the retrofit demonstration project were examined for a cost benefit relationship for new and retrofit padding. It appears that the cost per injury saved is in the order of 400 dollars for the new pads and about 110 dollars in the retrofit project. It is suggested that, although these data must be applied with caution, it would appear that the savings in terms of such costs as medical bills and lost schooling would greatly exceed the stated cost amounts, indicating a favorable cost benefit relationship. It is concluded that the future requirement for new pads on school busses required by a Federal Motor Vehicle Safety Standard can have important and positive minor injury reduction effects. The results of the research relating to new pads and retrofitted pads appear to be compatible. In this case, retrofit pads should be considered on a voluntary basis by the school bus operators. A state or Federal regulation appears appropriate which could specify uniform injury reducing and damage resistance qualities for the padding.

by Michael R. Appleby; Reynaldo R. Navarre

Automobile Club of Southern California, Los Angeles, Calif.

Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p411-9

1975 ; 5refs

Conference held in San Diego, Calif., 20-22 Nov 1975.

Availability: In HS-017 947

HS-017 982

## THE SCHOOL BUS SAFETY IMPROVEMENT PROGRAM

A program was conducted to develop and evaluate an improved body-on-chassis school bus which could be produced with only a modest cost and weight increase compared to current school busses. An improved structure was defined as one having a stronger structure--better able to resist damage and deformation in a crash or rollover accident. Accident avoidance characteristics of typical school busses (Baseline Busses) were evaluated and the accident avoidance characteristics of the Improved Busses were then compared to those of the Baseline Busses. The accident avoidance evaluation criterion was that the design changes, particularly the added weight necessary to strengthen the structure, should not significantly affect accident avoidance characteristics. Bus tests performed included accident avoidance tests, crash injury reduction tests, and structural component tests. The improved bus design includes: full-length longitudinal interior and exterior panels; reinforced floor/bow attachment; use of the seats as

HS-017 980

## MOTORCYCLE KINEMATICS AND INJURY PATTERNS

A clinical in-depth analysis has been conducted on motorcycle collision injuries occurring in California and the Southwest United States to determine and evaluate patterns of injury, mechanisms of injury, and sources of injury. Injuries result from three primary sources: the object struck; the final horizontal surface struck; and the motorcycle itself. The mechanism of injury was found to be dependent on whether the occupant kinematics were non-ejection, ejection, or deflection. While 40% of non-ejected occupants received fatal injuries, only 20% of ejected occupants were fatally injured. About 45% of non-ejected and 60% of ejected occupants received severe to critical injuries which were not fatal. About 70% of deflected occupants received severe to critical injuries and 15% sustained fatal lesions. Head injuries accounted for about 65% of the non-helmeted fatalities, while nearly 25% of the fatalities were from abdominal and/or thoracic injuries. Almost all occupants received injuries to more than one body region, several to most body regions. Head injuries were sustained by 90% of non-ejected occupants, 80% of ejected occupants, and about 70% of deflected occupants. The second most frequently injured body region was the legs, especially in the case of deflected occupants, 70% of whom received serious leg injuries. Persons who wore helmets that did not fail during the impact sustained a lower injury severity level. In this study, the percentage of non-helmeted occupants who experienced severe to fatal injuries was four times greater than the helmeted occupants. About one in five helmets failed during impact, generally due to chin strap or chin strap coupling failures. Injury patterns were found to differ as a function of crash dynamics, impact location, the struck vehicle, rider impact kinematics, and post crash ejection trajectories.

by A. W. Siegel; P. V. Hight; A. M. Nahum

University of California, D. B. Lent-Koop Trauma Res.

Group, San Diego, Calif.

Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p399-408

1975 ; 12refs

Conference held in San Diego, Calif., 20-22 Nov 1975.

Availability: In HS-017 947

structural elements; improved inner and outer window header rails and belt rails; reinforced roof corner; and improved body bow, roof strainer, and rear-cap construction. Structural improvements were achieved ranging from 33% to 57% as measured by reduction in deflection and intrusion for specified static loads and crash conditions. These improvements were accomplished with cost increases of 500 dollars and weight increases of 530 pounds. The improved busses showed greater roll stability during trapezoidal steer, sinusoidal steer, drastic steer, and brake tests. The structural improvements did not adversely affect braking and acceleration performance. It is recommended that school bus interiors and emergency exit provisions be improved.

by Paul F. Boulay; Sol Davis  
Ultrasystems, Inc., Dynamic Science Div., Phoenix, Ariz.  
Publ: HS-017 947, Conference of the American Association for  
Automotive Medicine (19th) Proceedings, Lake Bluff, Ill.,  
1975, p420-37  
1975 ; 2refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
Availability: In HS-017 947

HS-017 983

## **THE ABBREVIATED INJURY SCALE (1975 REVISION)**

The Abbreviated Injury Scale (AIS), first published in 1971, provided a comprehensive system for rating tissue damage which was acceptable to both physicians and engineers and which encompassed the overall needs of in-depth automotive crash investigation. The AIS has been adopted by the multidisciplinary accident investigation (MDAI) teams established by the U.S. Department of Transportation and by crash investigators worldwide. The most significant change in the 1975 revision of the AIS is that related to fatal injury codes 6, 7, 8, and 9, originally developed to differentiate between victims with varying combinations of fatal injuries. The severity of an injury will now be rated in the AIS without regard to whether or not the victim dies. AIS 6 has been redefined to include those injuries that invariably result in death given present emergency medical care capabilities, and fatal codes 7, 8, and 9 have been eliminated. A new code 9 has been created to indicate an injury with unknown severity, without regard to whether the victim dies. The Overall AIS is an assessment of the total effect of multiple injuries on a crash victim measured in terms of severity. This coding is a clinical judgment or estimate made by the coder and is not a sum, median, or average of the codings of the individual injuries. This code may be greater than the AIS coding of the most severe single injury, but is never less. An Injury Severity Score (ISS) recently developed and tested may be a suitable replacement for the overall AIS. The ISS is a mathematically derived code number based on the highest AIS codes in each of the three most severely injured body regions. The ISS requires that the injury be categorized by body region (head/neck, face, chest, abdomen, extremities, and general). It is recommended that the ISS and the Overall AIS be used simultaneously to permit further evaluation of both. An Injury Scale Dictionary provides more definitive injury descriptions for use in AIS coding than does the AIS. Copies of each of these are included.

Joint Com. on Injury Scaling of Society of Automotive Engineers; American Medical Assoc.; American Assoc. for Automotive Medicine  
Publ: HS-017 947, Conference of the American Association for Automotive Medicine (19th) Proceedings, Lake Bluff, Ill., 1975, p438-66  
1975 ; 15refs  
Conference held in San Diego, Calif., 20-22 Nov 1975.  
Availability: In HS-017 947

HS-017 984

## **APPLICATION AND TESTING OF AN INTERNAL AIR CUSHION BUMPER ON A STRUCTURALLY MODIFIED AUTOMOBILE**

A modified version of the pneumatic air cushion bumper has been incorporated into the basic design of a prototype automobile designed to provide improved structural performance during front, side, rear, and rollover collisions. A simple air bladder, recessed within a high-strength bumper bar, was supported by the front cross member of a modified frame which also served as a supplementary volume to reduce peak pressures and loads. Check valves were located between the bladder and the frame chamber to limit energy of rebound. Static tests were performed in a Calspan Vehicle Static Crushing Machine (VSCM), in which bumper face bar displacement with respect to the vehicle front structure was measured with a linear potentiometer. The pneumatic bumper system was subjected to a series of low-speed dynamic tests in which the test vehicle was propelled by a powered winch towing system with automatic speed control and the impacted object was a flat-faced concrete barrier. Instrumentation for the dynamic bumper tests recorded impact velocity, vehicle g-level, bladder pressure, and cross member reservoir pressure. High-speed crash tests were also performed to determine the structural crashworthiness of aspects of the modified bumper system. It is concluded that this program has demonstrated the design flexibility of the air cushion bumper in adaptation to an alternative bumper design wherein the cushion is internally located. The test results have demonstrated: capability of withstanding barrier impacts in the neighborhood of 6 mph with no significant physical damage, with similar performance expected at speeds up to 10 mph; dynamic performance characterized by a relatively constant load/stroke, indicating efficient energy absorption; effective rebound limitation capability provided by check valves with attendant repressurizing by bleed holes; and close agreement of test results with analysis based on adiabatic gas compression giving good confidence in performance prediction.

by Ernest J. Merz; James E. Greene  
Safety Consultants; Calspan Corp.  
Contract DOT-HS-053-2-487  
Rept. No. SAE-750012 ; 1975 ; 12p 5refs  
Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 986

## **EVALUATION OF DIESEL ENGINE PERFORMANCE WITH INTAKE AND EXHAUST SYSTEM**

## THROTTLING. VOL. 1. TEXT AND APPENDIXES A THROUGH H. FINAL REPORT

An investigation was conducted to quantify the effects of intake and exhaust restrictions and load-speed scheduling on the radiated noise from four diesel truck engines, produced by different manufacturers. The engines tested included: a naturally aspirated 4-cycle direct-injection engine, Cummins NHC-250; a turbocharged 4-cycle precombustion chamber engine, Caterpillar 1673C; a turbocharged 4-cycle direct-injection engine, Mack ENDT-675; and a 2-cycle direct-injection blower scavenged engine, Detroit Diesel 6-71. Noise and performance test measurements were made at three speed-load combinations: full load at manufacturer's rated speed; speed for maximum torque development; and at an intermediate speed at full load. Sound power measurements were made in an acoustically modified engine performance test cell. The noise associated with intake, exhaust, and cooling and their respective ducting systems were appropriately abated to permit quantification of engine radiated noise. Exhaust emission data including temperature and performance data were also monitored. Engine radiated noise was not significantly affected by intake pressure restrictions up to 60 inches water or exhaust restrictions up to 90 inches water. The precombustion chamber turbocharged engine exhibited lower sound output than the naturally aspirated engine with respect to the mechanical power available under various load-speed conditions. Calculated engine sound pressure levels projected to 50 feet gave noise levels ranging from 77 to 83 decibels at rated engine speed. Some special tests were conducted to: establish a non-firing noise level of the engine and accessory equipment; examine the sound pressure levels in the room with the Caterpillar engine operated normally but at part load as compared to the engine operated with the turbine removed from the turbocharger; examine turbocharger effect using the Mack engine; and study the effect of thermal insulation on the coolant requirements for the Cummins engine. Complete, detailed engine test data are appended.

by R. Hern; B. Eccleston; W. Marshall  
Energy Res. and Devel. Administration, Bartlesville Energy  
Res. Center, P. O. Box 1398, Bartlesville, Okla. 74003  
Contract RA-73-2  
Rept. No. TSC-OST-74-42.1; 1975; 143p  
Report for Nov 1972-May 1974.  
Availability: NTIS

HS-017 987

## EVALUATION OF DIESEL ENGINE PERFORMANCE WITH INTAKE AND EXHAUST SYSTEM THROTTLING. VOL. 2. APPENDIX 1. FINAL REPORT

Noise analysis data from an investigation conducted to quantify the effects of intake and exhaust restrictions and load-speed scheduling on the radiated noise from four diesel truck engines produced by different manufacturers are presented. The engines tested included: a naturally aspirated 4-cycle direct-injection engine, Cummins NHC-250; a turbocharged chamber 4-cycle precombustion chamber engine, Caterpillar 1673C; a turbocharged 4-cycle direct-injection engine, Mack ENDT-675; and a 2-cycle direct-injection blower scavenged engine, Detroit Diesel 6-71. Noise analysis data are presented on the following test results: the effect of intake and exhaust restriction on the NHC-250 engine sound power level and 50-foot sound power level spectrums; the effect of intake and exhaust restriction on

the ENDT-675 engine sound power level and 50-foot sound power level spectrums; the radiated sound power level spectrums for the ENDT-675 load-speed engine; the effect of intake and exhaust restriction in the 1673C engine sound power level and 50-foot sound power level spectrums; the radiated sound power level spectrums for the 1673C load-speed engine; the effect of intake and exhaust restriction on the 6-71 engine sound power level and 50-foot sound power level spectrums; and the radiated sound power level spectrums for the 6-71 load-speed engine. Sound power measurements were made in an acoustically modified engine performance test cell.

by R. Hern; B. Eccleston; W. Marshall  
Energy Res. and Devel. Administration, Bartlesville Energy  
Res. Center, P. O. Box 1398, Bartlesville, Okla. 74003  
Contract RA-73-2  
Rept. No. DOT-TSC-OST-74-42.2; 1975; 190p  
Report for Nov 1972-May 1974.  
Availability: NTIS

HS-017 988

## THE PERFORMANCE OF "CONVENTIONAL" HYDROGEN/AIR ENGINES: THEORETICAL CYCLE ANALYSIS

Ideal-cycle calculations are presented for hydrogen/air, Otto-cycle engines. The purpose for considering such theoretical results was to provide a concrete, common basis for establishing the thermodynamic potential of hydrogen in such engines and a basis for evaluating and interpreting experimental data. Attention is confined to theoretical treatment of hydrogen/air engines which, like conventional gasoline engines, induce a premixed fuel/air charge into the cylinder. The theoretical results achieved indicate that substantially higher efficiencies should be obtainable with quality-controlled hydrogen compared with current throttled gasoline use. This is not apparently true under gasoline-engine conditions of wide-open-throttle and steady speed, but is a consequence of: rich-mixture, gasoline engine operation at idle and for acceleration, and large throttling losses at light load, such as idle or very low speed cruise. Accounting for engine friction and for the lower maximum power of a hydrogen engine is also seen theoretically to decrease the efficiency benefit of quality-controlled hydrogen at low part-loads. The likely routes to improved efficiency in hydrocarbon-fueled engines will decrease the relative efficiency gain of hydrogen as an alternative fuel. It appears from the present theoretical foundations that stratified-charge engines (quality-controlled) might put hydrocarbon fuels at a comparable efficiency level with hydrogen.

by Richard B. Cole  
Stevens Inst. of Tech., Dept. of Mechanical Engineering  
Publ: Intersociety Energy Conversion Engineering Conference  
(10th) Record, New York, 1975, p131-5  
Rept. No. SAE-759023; 1975; 13refs  
Conference held at the University of Delaware, Newark, 18-22 Aug 1975.  
Availability: See publication

## A UNIFIED ANALYSIS OF HYDROGEN FUEL FOR PASSENGER CARS FROM POLLUTION AND PERFORMANCE POINT

The levels of nitric oxide emitted from a hydrogen/air fueled internal combustion engine and the performance of such an engine under different operating parameters were investigated. Nitric oxide (NO) prediction is based on a model that incorporates the essential kinetic mechanism for the formation and decomposition of NO and other species thought to be important in the reaction scheme. The model study is based on the assumption that the mixture is carbureted and is in a state of complete homogeneity prior to ignition. NO predictions show similar behavior to experimental data obtained by other investigators and indicate high NO emissions around a fuel air equivalent ratio of 0.85, but the possibility of using still leaner mixtures gives a low specific NO in the exhaust gases. Wide flammability limits of hydrogen can be used either to run the engine on hydrogen supplemented fuel with regular gasoline as the main fuel or using stratification, both of which would have low NO and high thermal efficiency.

by Keshav S. Varde  
University of Michigan-Dearborn, Dept. of Mechanical Engineering, Dearborn, Mich. 48128  
Publ: Intersociety Energy Conversion Engineering Conference (10th) Record, New York, 1975, p136-41  
Rept. No. SAE-759024 ; 1975 ; 23refs  
Conference held at the University of Delaware, Newark, 18-22 Aug 1975.  
Availability: See publication

HS-017 990

## SIMULATION OF AUTOMOBILE MILEAGE AND EMISSIONS BY USE OF DYNAMIC MODELS AND REAL COMPONENT DATA

A program for computing continuously the instantaneous fuel consumption and emissions of passenger cars has been constructed. The program, called the Automobile Propulsion Simulator, includes the modelling of the dynamic interactions within the powerplant and chassis, making it possible to investigate transient effects that are masked with simulation models based on the assumption of operation at a series of steady-state conditions. An all-digital batch version is used for fast evaluation of changes in fuel economy, emissions, and other factors caused by vehicle component changes. A real-time hybrid computer version, in combination with a driver compartment simulator, allows drivability and other human factors to be evaluated and is particularly useful in the study of advanced and unorthodox propulsion concepts. Good results have been obtained in the prediction of fuel consumption over various driving cycles, in determining changes in fuel consumption from changes in vehicle component parameters, and in studying power train dynamics. The program keeps a running account throughout the driving cycle of where the energy from the prime mover goes, such as how much is lost in each component of the drive train, in rolling resistance, in aerodynamic drag, and how much is thrown away in braking. A joint probability density print-out for the engine allows the determination of the fraction of time spent at each torque-speed condition over a driving cycle. Block diagrams of the Automobile Propulsion Simulator, and the torque converter model are provided and predicted and measured fuel consumption and emissions and vehicle variations from the base digital

computer simulation for a 1973 four cubic inch displacement engine are tabulated.

by R. Radtke; D. Kapellen; A. Frank; N. Beachley  
University of Wisconsin, Madison; Shell Devel. Co., Wood River, Ill.  
Publ: Intersociety Energy Conversion Engineering Conference (10th) Record, New York, 1975, p142-9  
Rept. No. SAE-759025 ; 1975 ; 5refs  
Conference held at the University of Delaware, Newark, 18-22 Aug 1975.  
Availability: See publication

HS-017 991

## COMPUTER AIDED DESIGN OF BODY ROOF SIDE RAIL

Using the body roof side rail as a typical design project, manual and Computer Aided Design (CAD) graphics techniques were compared to explore the design areas for effective utilization of CAD techniques. The key to the whole concept of CAD has been the establishment of a large scale Common Data Base (CDB). Experience has shown that in terms of real time design turnaround, data acquisition was the decisive factor in the cost effectiveness of CAD. Early experience showed that data acquisition efforts were often duplicated, real time acquisition was prohibitive on a part-programming basis, and training was too often extended before becoming CAD operational due to the preoccupation with input data requirements. With the cooperation of all the affected areas in a large design organization, the establishment of the CDB eliminates the major restrictions to the implementation of the CAD. With the CDB, it has been possible to concentrate on the exploitation of the CAD assets of greater accuracy and inherent speed in typical repetitive design functions. While human judgment and evaluation is still the critical element in the design scheme, the CAD provides the resources for utilizing more human design creativity with minimal involvement in non-creative design tasks.

by Conrad S. Allman, Jr.  
Chrysler Corp.  
Rept. No. SAE-750021 ; 1975 ; 13p 5refs  
Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-017 992

## AN ANALYTICAL EXAMINATION OF THE ROLE OF SMALL PERTURBATIONS IN OPERATING PARAMETERS ON CYCLIC PRESSURE VARIATIONS IN AN ENGINE

The response of an autoigniting engine fueled with hydrogen to small perturbations of operating variables was established analytically over a number of consecutive cycles. This simulation of a four-stroke engine involved the mixing of a fresh charge assumed to be homogeneous with the residual gases from the previous cycle. The resulting mixture is then compressed and subsequently expanded to the exhaust stage. During the compression and expansion stages reaction kinetics were considered to predict the changes in the concentrations of the contents of the cylinder in detail and their properties with time. Using this formulation it was possible to follow the history of the engine cylinder gases over a number of consecutive cycles. To consider the role of any operating param-

ter, its value was perturbed by a small factor, either over only one cycle or periodically over a number of cycles, and the consequences of the perturbation were observed on subsequent cycles. The effect of perturbations of the following factors were examined: properties of the fresh charge, including pressure, temperature, and equivalence ratio; exhaust and induction pressures; cylinder wall temperature; engine speed; and the chemical reactivity of the exhaust gases. Generally it was found that any small change that produced an increase in the length of the ignition delay tended to have a significant and more lasting effect on cycle variables, such as maximum cycle temperature and pressure, exhaust temperature, and composition, than a change bringing about an earlier on-set of ignition. Slight fluctuations in the mean charge temperature at intake valve closure was found to be the most effective contributor to cyclic variation. Less pronounced was the effect of variations in the mean wall temperature or the heat transfer coefficient. Fluctuations in the equivalence ratio of the charge was also an effective contributor to cyclic variation, particularly for mixtures near the ignition limits. It would appear that, at least with hydrogen as a fuel, the thermal rather than the kinetic nature of the residuals is the more effective contributor to cyclic dispersion.

by G. A. Karim; G. Sarpal  
University of Calgary, Alta., Canada; Canadian Kellogg Co., Ltd., Toronto, Ont., Canada  
Publ: Intersociety Energy Conversion Engineering Conference (10th) Record, New York, 1975, p159-61  
Rept. No. SAE-759027; 1975; 6refs  
Conference held at the University of Delaware, Newark, 18-22 Aug 1975.  
Availability: See publication

HS-017 993

### LEAN MIXTURE ENGINE TESTING AND EVALUATION PROGRAM

Tests were made on stock and lean burn versions of a 1973 350 cubic inch Chevrolet V-8 engine using a water brake engine dynamometer to examine fuel consumption and emissions. The lean burn engine achieved peak thermal efficiency at an equivalence ratio of 0.75 and a spark advance of 60° BTDC. At this condition the lean burn engine demonstrated a 10% reduction in brake specific fuel consumption compared with the stock engine; however nitrogen oxide (NOx) and hydrocarbon emissions were higher. With the use of spark retard and/or slightly lower equivalence ratios, the NOx emissions performance of the stock engine was matched while showing a 6% reduction in brake specific fuel consumption. Hydrocarbon emissions exceeded the stock values in all cases. Diagnostic data indicate that lean performance in the engine configuration tested is limited by ignition delay, cycle-to-cycle pressure variations, and cylinder-to-cylinder distribution.

by M. W. Dowdy; F. W. Hoehn; D. C. Griffin  
Jet Propulsion Lab., Pasadena, Calif.  
Contract NAS7-100  
Publ: Intersociety Energy Conversion Engineering Conference (10th) Record, New York, 1975, p150-8  
1975; 9refs  
Conference held Univ. of Delaware, Newark, Del., 18-22 Aug 1975, in cooperation with Transportation Systems Center, Cambridge, Mass.  
Availability: See publication

HS-017 994

### HAZARD ANALYSIS OF MINI-BIKE RELATED INJURIES

A study of mini-bike-related accident injuries, including a nationally representative surveillance system and in-depth investigations of certain accident victims, is presented. The National Electronic Injury Surveillance System (NEISS), designed to develop statistically valid, product-related injury data, is a computer-based network of 119 selected short term hospital emergency rooms located throughout the country. Injury data is transmitted daily to a central computer via teletype terminals in the different hospitals. Victim and injury information is recorded regarding: age, sex, injury diagnosis, body part involved, disposition, and severity rating. The in-depth investigations are essentially personal interviews with the victim and/or his family or witnesses. The investigator records demographic data and obtains a detailed description of the accident and, when possible, a sample of the product (mini-bike) involved. Since January 1, 1973 the NEISS has amassed reports of more than 1,000 mini-bike-related injuries. Children 10 to 14 years of age represented 51 percent of the total reported injuries. The ratio of injured males to females was 4 to 1. Lacerations and contusions/abrasions accounted for over 60 percent of the injuries. Injuries to the legs, primarily the lower leg, accounted for one-third of the cases. Victims were treated and released most of the time; only 6 percent were hospitalized. Eighty percent of the accidents for which the location was known occurred around the home, while 20 percent occurred on public streets. According to in-depth investigations, loss of control, collision, mechanical and structural problems, and contact with parts were the major factors leading to mini-bike-related injuries. An appendix summarizes 60 in-depth investigations of these injuries giving probable accident cause, rider age, type of injury, and mini-bike make.

Consumer Product Safety Commission, Bureau of Epidemiology, Washington, D.C. 20207  
Rept. No. NHTC-1263-74-H011; 1974; 38p 4refs  
Availability: Corporate author

HS-017 995

### ANNUAL REPORT AND RESOLUTIONS OF THE COUNCIL OF MINISTERS (21ST). EXTRACT COPY

An annual report of the European Conference of Ministers of Transport conducted to promote the maximum use and development of European International land transportation and the organizations concerned with it is presented. Resolutions concerning various road and freight transport problems and reports, approved by the Council of Ministers, are included. These concern: international road transport regulations; information exchange on infrastructural investment projects; roll-on/roll-off transport of unaccompanied trailers and semi-trailers; rural speed limits; two-wheeled vehicle (bicycle, moped, and motorcycle) safety problems; road traffic rules and road signs; railway transport; and road accidents, including injuries and fatalities for 1973. Lists of officers of the Conference and delegates are annexed.

European Conference of Ministers of Transport  
1974; 183p  
Council held in two sessions, Vienna, 19-20 Jun 1974 and Paris, 3 Dec 1974.  
Availability: Reference copy only

HS-017 996

# **MULTIDISCIPLINARY ACCIDENT INVESTIGATION. G. M. C. SCHOOL BUS/ROLLOVER**

A 1973 GMC/Bluebird School Bus was southbound on a rural Ontario highway at an estimated 30 mph. The 35 year old male driver was distracted by the students and shifted his gaze to see what was happening. The bus drove off the roadway, across the narrow right shoulder, and into the ditch. When steered back, the rear wheels did not mount the slope until striking a blockage in the ditch. The right rear corner of the bus struck a utility pole. Then, the whole vehicle turned sharply left and overturned onto the road and left ditch on its right side. Neither the driver nor any of the 38 children (aged 5 to 13) aboard the bus were more than slightly injured. One student who had bruises to the abdominal wall was hospitalized to check for internal injuries. It is concluded that: the driver allowed his attention to be diverted too long from the driving task and ran off the roadway; had the driver simply allowed the vehicle to decelerate without attempting to return to the roadway no crash would have occurred although the vehicle may have been damaged; and the heavy winter clothing worn by the occupants prevented abrasions. Photographs of the damaged bus and the accident site, and a copy of the complete collision performance and injury report are included.

by Merritt M. Davis; Lawrence Black  
University of Toronto, Dept. of Civil Engineering, Toronto, Ont., Canada  
Contract 98478

Rept. No. TOR-059-75 ; 1975 ; 184p  
Includes French resume. Prepared for the Director of Road and Motor Vehicle Traffic Safety, Ministry of Transport, Ottawa, Canada.

Availability: Director, Road and Motor Vehicle Traffic Safety, Ministry of Transport, Ottawa, Ont., Canada

HS-017 997

# **EFFECT OF VARIATION OF SPEED LIMITS ON INTER-CITY BUS FUEL CONSUMPTION, COACH AND DRIVER UTILIZATION, AND CORPORATE PROFITABILITY. FINAL REPORT**

The effect of speed limit and passenger load on fuel consumption was determined using actual intercity buses with simulated passenger loads over different types of terrain. The routes travelled included relatively flat terrain (the 200 miles from Washington, D.C. to Norfolk, Va.), rolling hills (the 190 miles from Boston to Westover, Mass.), and rolling hills plus mountains (250 miles from Boston to western Massachusetts, crossing the Berkshires). Also, laboratory-type measurements were made on four intercity buses using a chassis dynamometer facility. Fuel flow measurements made during these tests were analyzed in conjunction with data obtained on the road tests to point out possible discrepancies. Computer analysis of the fuel consumption parameters for a typical bus was also performed to further corroborate experimental data. A brief survey of pertinent literature, users and industrial suppliers of engines was conducted to ascertain the effects of reduced speed limits on maintenance. The operational impacts on intercity bus companies were also studied. A specific in-depth analysis was conducted for one typical operator. Principal conclusions were: increased fuel consumption results from higher speeds in the 50-60 mph range; terrain is an important factor in determining the effect of speed limit on fuel consumption; no significant fuel savings are expected for intercity buses if

speed limits are reduced in the 50-60 mph range over mountainous terrain; and reducing speed limits should reduce maintenance costs but increase direct operating costs.

by A. J. Broderick; P. Davis; L. Leist; H. Miller; E. Klaubert  
Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142  
Rept. No. DOT-TSC-OST-75-4 ; 1975 ; 139p  
Report for Dec 1973-Jul 1974.  
Availability: NTIS

HS-017 998

# **EMERGENCY MEDICAL SERVICES: THE RESEARCH GAPS**

The need for research in many areas of the operation of emergency medical services (EMS) is examined in detail. Research gaps include: detailed epidemiologic and other data on the nature, amount, and distribution of clinical conditions that an EMS system is expected to respond to; systematic cross-cultural comparisons; theoretical application of existing organization concepts to EMS; and serious attempts to relate EMS to the wider ambulatory health care system; research into the actual utilization of resources in EMS as well as the detailed process of care received; and EMS evaluation from the viewpoint of patient outcome. Various papers presented at the November 1973 meetings of the American Public Health Association are reviewed as expanding research activity in the indicated directions.

by Geoffrey Gibson  
Publ: Health Services Research v9 p6-21 (Spring 1974)  
1974

Availability: See publication; Geoffrey Gibson, Bureau of Health Services Research, HRA/DHEW, Parklawn Bldg., Room 15-35, 5600 Fishers Lane, Rockville, Md. 20852

HS-017 999

# **BOTTOMING-CYCLE ENGINES USE WASTE HEAT TO SAVE GAS**

The bottoming-cycle engine, a coupling of a conventional internal combustion engine with a smaller Freon vapor engine which runs on the normally wasted heat of the engine exhaust, is discussed. The smaller engine is an external combustion Rankine-cycle engine. The fuel economy, heat dissipation, and emissions characteristics of the engine are considered. Photographs, a drawing, and a diagram of the bottoming-cycle engine are included.

by E. F. Lindsley  
Publ: Popular Science v208 n1 p82-6 (Jan 1976)  
1976

Availability: See publication

HS-018 000

# **BIKEWAY SYSTEM PLANNING AND DESIGN MANUAL**

A manual is presented to assist urban communities in the development and implementation of a bikeway system through a process consisting of a series of interdependent steps. The following areas of concern are discussed in detail: needs and wants, organization, and goals and objectives on a community

level; data inventory and forecasts; system development; system initiation (system prioritization, alternative design concept development, analysis of alternates, and design concept selection); bikeway design; and bikeway evaluation. Bikeway system plans, photographs, signs, and special features are also illustrated.

by Joseph R. Beck; Richard J. Carlson; Donald H. Carr; Robert D. Theisen  
Seattle Engineering Dept., Traffic and Transportation Div.  
1975 ; 171p refs

Supported by the National Hwy. Traffic Safety Administration and the Washington Traffic Safety Administration.  
Availability: Corporate author

HS-018 001

## BICYCLE SAFETY STUDY. FINAL REPORT

The purpose, method, and conclusions of the following major tasks are presented: a retail bicycle sales survey which predicted a continued high sales volume for the next five years; a double cordon count of bicycles in a highly bicycle-oriented part of Seattle, Washington, where about 7,000 bicycles were counted; a study of 89 bicycle/motor vehicle accident investigation records in areas of high accident frequency; a bicycle rider questionnaire which had a return of 1717, 18 percent; a review of 688 reported bicycle/motor vehicle accidents within Seattle from 1970 to 1973; and an evaluation of an on-the-street type bikeway delineated essentially by painted line and signing. Also included is a general description of the planning method and design decision process for a bikeway funded and installed by the city of Seattle. The major conclusions are: retail bicycle sales and bicycle/motor vehicle accidents frequencies will continue to rise; there is no simple correlation between bicycle volumes and accident frequencies on a given roadway; a majority of bicycle fatalities are a result of head injuries; the proportion of all bicycle/motor vehicle accidents involving persons 20 years 00d and older is increasing; and a well-planned, designed and constructed bikeway can reduce bicycle/motor vehicle and other motor vehicle accidents.

Seattle Engineering Dept., Traffic and Transportation Div.  
1975 ; 140p 75refs  
Supported by the National Hwy. Traffic Safety Administration and the Washington Traffic Safety Administration.  
Availability: Corporate author

HS-018 002

## SEX DIFFERENCES IN DRIVING PERFORMANCE

Sex differences in the psychomotor performance characteristics of 89 male (from 18 to 51 years old) and 74 female (from 16 to 48 years old) licensed drivers were evaluated through the use of a nonprogrammed point light source driving simulator with a mockup automobile body and a 6x12 foot rear projection screen. Thirteen measurements of steering input, accelerator input, speed maintenance, and lateral placement were made. Data were subjected to [1 series of multiple discriminant analyses' Discrimination was found between sex groupings, sex/violation groupings, 164sex/accident groupings, sex/driving exposure groupings, sex/type of driving groupings, sex/risk groupings, and sex/driver education groupings. Since basic differences were demonstrated, aspects of the transportation system, such as accident countermeasure efforts and driver education programs which have been primarily

developed on the basis of male driving performance data, might be in need of re-evaluation.

by Roger E. Hagen  
Publ: Human Factors v17 n2 p165-71 (Apr 1975)  
1975 ; 7refs.  
Availability: See publication

HS-018 004

## AIR WEDGE DISC BRAKES FOR HEAVY TRUCK FRONT AXLES

The general vehicle application, design criteria and part description of the Rockwell air-wedge actuated disc brake combined with laboratory dynamometer and test truck evaluation support the feasibility and desirability of applying air actuated disc brakes to front axles of heavy trucks and tractors. Disc brakes furnish increased side to side vehicle stability as a result of simultaneous brake application timing inherent in the disc brake design and the essentially constant input-output ratio of the disc brake due to the non-energizing characteristic and increased vehicle stability during braking as a result of constant disc brake torque output with respect to vehicle speed and dynamic load transfer onto the front axle. Air-wedge disc brake compatibility with conventional air systems and anti-skid control units is excellent. Initial vehicle testing produced excellent compatibility between front air-mechanical disc brakes and rear drum brakes.

by Bruce D. Anderson  
Rockwell International  
Rept. No. SAE-750734 ; 1975 ; 10p  
Presented at the West Coast Meeting, Seattle, Wash., 11-14 Aug 1975.  
Availability: SAE

HS-018 005

## AUTOMOBILE INSURANCE LOSSES COLLISION COVERAGE. VARIATIONS BY MAKE AND SERIES 1975 MODELS DURING THEIR FIRST YEAR

Variations in both the frequency and size of collision claims for damage to 1975 private passenger vehicles of 12 domestic and 12 foreign makes during their first 12 months of availability--September 1974 through August 1975--are described. They are based on data from collision coverages supplied by seven insurance companies: Allstate, Kemper, Liberty Mutual, Nationwide, Prudential, State Farm, and Travelers. A loss payment summary by make, series and body, and claim frequency details by make, series, and body by operator age group and coverage are tabulated. The following data relationships are discussed: standardized results for all series combined; variations between individual series; variations within market class and body style; comparisons between market classes; comparisons between body styles; claim frequency details by make and series; and average loss payment details by make and series.

Highway Loss Data Inst., Watergate Six Hundred,  
Washington, D.C. 20037  
Rept. No. HLDI-R75-2 ; 1975 ; 25p 3refs  
Availability: Corporate author



HS-018 006

**CHARACTERISTICS OF LARGE-TRUCK  
ACCIDENTS AS REPRESENTED IN TEXAS  
ACCIDENT DATA AT HSRI. FINAL REPORT**

Data maintained on large-truck accidents were assessed to establish which files contain the most useful information, to establish what those data show about large-truck accidents, and to develop recommendations on means of improving the quality of data collection on large-truck accidents. Police-reported accident data for the state of Texas were found to be the best available data, but they contain several weaknesses, which are discussed. Findings concerning large-truck accidents are presented in terms of: month, day, and hour of accident; roadway; weather; accident configuration; truck type; vehicle defects and damage; driver age; injury frequency and severity factors. In addition, truck and passenger car involvements are compared. Recommendations are presented concerning the necessity of improving the classification of truck types, the collection of vehicle data, and the development of a truck damage scale.

by John A. Green  
University of Michigan, Hwy. Safety Res. Inst., Ann Arbor,  
Mich. 48105  
Rept. No. UM-HSRI-SA-75-12 : 1975 : 65p 38reps  
Report for Feb 1975-Jun 1975. Sponsored by the Motor  
Vehicle Manufacturers Assoc., 320 New Center Bldg., Detroit,  
Mich. 48202.  
Availability: Corporate author

HS-018 007

**THE VOLKSWAGEN EXPERIMENTAL SAFETY  
VEHICLE**

Volkswagen's work on an experimental safety vehicle (ESVW) is described. To obtain reference values during the ESVW development, two standard vehicles (an Audi 100 and a VW 411) were modified and subjected to various handling and accident avoidance tests. Fourteen destructive and 30 non-destructive tests were conducted with collision test frames, which have force-distortion characteristics similar to the ESVW. Another 40 crash tests were carried out with standard vehicles modified by the installation of ESVW components. The following ESVW components and characteristics and their test programs are discussed: braking system (anti-skid system); braking performance (service brake, fade tests, load-dependent brake performance, parking brake, and emergency brake); tire and wheels; axles and steering (front axle, front suspension, rear axle, rear axle support, rear suspension, steering, and adjustment of steering wheel and pedals); steering tests (data of test vehicle, steady state yaw response, transient yaw response, and returnability); handling (lateral acceleration, control at breakaway, directional stability, crosswind sensitivity, pavement irregularity sensitivity, steering control sensitivity, and overturning immunity); visibility (windshield wipers, windshield washer, and headlight washing system); lighting and control system; engine (passing times and emissions); crashworthiness (structure, occupant crash protection and vehicle aggressivity, and test results); restraint system (theoretical considerations, system description, sled test results, and vehicle test results); benefit cost considerations; other restraint systems; benefit/cost considerations; and cars with improved structures. Future ESVW specifications are proposed and future evaluations are described.

Volkswagenwerk AG, Res. and Devel. Center, Wolfsburg,  
West Germany  
1973 : 98p 14reps  
Availability: Corporate author

HS-018 008

**EVALUATION OF MEETING BEAMS [HEADLAMPS]  
BY FIELD TESTS AND COMPUTER SIMULATION.  
FINAL REPORT**

Field experiments were conducted to evaluate alternative meeting beams in terms of visibility distances and glare effects. Conventional American and European low beam head lamps were used as a basis for comparison with the experimental mid beams. Two identical station wagons were driven towards each other on a 4,000 foot test course. They were equipped with a front-mounted panel to which the headlamps were attached, photodetector systems to mark target positions, and strip chart recorders for data collection. Targets consisted of a 24x30 inch flat black background on which reflective faces were mounted. A total of 16 subjects (nine male, seven female, 20-51 years old, two per car per run) participated in the program. Computer simulation evaluations were first made to determine aiming specifications for the lamp used to augment the low beams in providing midbeams. Field tests suggest that, a mid beam composed of the ECE low beam and a Type-III lamp, can be expected to provide about a 20% increase in seeing distance for targets along the right side of the road with negligible increases in glare for meetings on straight, flat, two-lane roads. There was generally good agreement between computer simulation predicted visibility distances and those obtained in the field test. It was concluded that improved meeting beams should incorporate the general characteristics of the mid beams used in these tests and that, based on the test findings and those of previous computer simulations, the mid beams should be dimmed when meeting another vehicle which is in the outside lane and when following another vehicle at distances of less than about 200 feet.

by Rudolf G. Mortimer; Paul L. Olson  
University of Michigan, Hwy. Safety Res. Inst., Ann Arbor,  
Mich. 48105  
Contract UM-7102-C128  
Rept. No. UM-HSRI-HF-74-27 : 1974 : 53p 4reps  
Report for 1 Jul 1973-30 Jun 1974. Sponsored by the Motor  
Vehicle Manufacturers Assoc., 320 New Center Bldg., Detroit,  
Mich. 48202.  
Availability: Corporate author

HS-018 009

**AUTOMOBILE INTERSECTION COLLISIONS--AN  
ANALYTICAL AND EXPERIMENTAL  
INVESTIGATION OF THE CRASH PHASE**

An investigation is made into the crash phase of automobile intersection collisions in which the predominant force is due to the impact, and the external forces on the vehicle, such as tire friction, may be neglected. Analytical as well as experimental (full-scale and 1/16 scale model side impacts) methods were used to show that the automobile crash phenomena may be explained macroscopically by rigid body impact theory. Analysis of experimental results indicated the numerical range of the coefficient of friction between the colliding vehicles and the coefficient of restitution necessary to explain the crushing characteristics of the automobile structures and the final

velocities at the end of the crash phase for different modes of intersection collisions.

by Haluk Bekirglu

Publ: Accident Analysis and Prevention v7 n4 p225-37 (Dec 1975)

1975 ; 8refs

Availability: See publication

HS-018 010

## **DRIVER PERFORMANCE MEASUREMENT BASED ON DYNAMIC DRIVER BEHAVIOR PATTERNS IN RURAL, URBAN, SUBURBAN AND FREEWAY TRAFFIC**

A method of driver performance measurement was developed using a content validity and systems psychology basis which showed very high reliability. For evaluation purposes two new groups of observers were trained by the original team of experts. Extensive statistical analysis of results showed that their results were of similar very high reliability and validity. This method is applicable to research where the conventional large group, long duration type of research in terms of accident records cannot be validly used. The method can be used for research comparing small groups to improve driver education or driver license examining methods. Reliable and valid results cannot be expected unless the measurements are made by observer/raters with proper background who have had special training of the type which has been demonstrated and evaluated.

by T. W. Forbes; R. O. Nolan; F. L. Schmidt; F. E. Vanosdall  
Contract FH-11-7627

Publ: Accident Analysis and Prevention, v7 n4 p257-80 (Dec 1975)

1975 ; 11refs

Presented before the Com. on Rd. User Characteristics of the Hwy. Res. Board, Washington, D. C. 21 Jan 1974.

Availability: See publication

HS-018 011

## **AN EVALUATION OF SOME ADDITIONAL FACTORS INFLUENCING THE EFFECTIVENESS OF WARNING LETTERS**

The effectiveness of two types of warning letters and an informational pamphlet in reducing the subsequent collision and conviction records of drivers with previous convictions is examined. A sample of 16,513 pre-negligent California drivers were selected from driver records for the study. An additional study objective was to determine the effectiveness of a follow-up reinforcement letter sent to those drivers who were collision and conviction free for six months after the initial letter. The results six months subsequent to treatment (the first letter) showed no significant treatment effects on convictions, but a positive pamphlet effect on collisions. On convictions, however, there was a main effect attributable to type of warning letter as well as an interaction between type of warning letter, pamphlet condition, and follow-up reinforcement. No treatment conditions were significantly influenced by subject characteristics.

by William V. Epperson; Richard M. Harano  
Publ: Accident Analysis and Prevention v7 n4 p239-47 (Dec 1975)

1975 ; 6refs

Supported by the Federal Hwy. Administration, Contract 0B0147 through Interagency Agreement 0A13307 with the California Dept. of Transportation, Div. of Highways.

Availability: See publication

HS-018 012

## **A MODEL FOR EVALUATING THE EFFECTIVENESS OF MOTOR VEHICLE INSPECTION PROGRAMS**

A statistical model for the evaluation of the effectiveness of motor vehicle inspection programs in reducing highway crashes is presented. The model is based on the assumption that the waiting time between highway crashes follows an exponential distribution. Since highway crashes are relatively rare events, it is assumed that the length of the study period is such that censoring occurs. Under these assumptions, maximum likelihood estimates of the mean waiting time until a crash for the non-inspected (inspected) vehicles is obtained and the corresponding test statistic is derived. As mechanically-caused accidents are but a small part of the overall accident picture, and since inspection should only affect this portion, sample size requirements are investigated for various combinations of the mean waiting time; increase in average time until a crash due to the effect of inspection; length of study period; and a probability of Type I error equaling probability of Type II error. For a reasonable increase in average time until a crash due to the effect of inspection, the sample required is quite sizable.

by Michael J. Symons; Donald W. Reinfurt

Grant NIH-S-T01-ES00133

Publ: Accident Analysis and Prevention v7 n4 p281-8 (Dec 1975)

1975 ; 8refs

Partially supported by the North Carolina Governor's Hwy. Safety Prog. and the Insurance Inst. for Hwy. Safety.

Availability: See publication

HS-018 013

## **DRIVING BEHAVIOR AND PERSONALITY OF YOUNG MOPED DRIVERS**

Driving behavior of adolescent moped drivers in real traffic situations was compared to the results of an analysis of personality. Observation was carried out by three trained observers following by scooter and observing 700 moped drivers, aged 16-18 years. The subjects did not know that they were observed. Two groups were formed according to a rating scheme which consisted of 10 criteria of driving behavior: 105 moped drivers with good and 105 with bad adaptation in traffic. By means of testing and standardized interviews the two extreme groups were examined for psychological and sociological differences. The largest differences between good and bad moped drivers were found in the variables of: family milieu; need for achievement; attitude in traffic; respecting authority and norms; strictness of education; and risk taking. Some of the subjects were observed a second time while they were aware of being observed. By means of factor analysis, the results of both observation methods (with and without knowledge of being observed) were compared. The com-

parison showed that both methods agreed to a great extent and measured almost the same factors. The knowledge of being observed caused a general tendency of levelling those behavior characteristics which show to a medium degree in the "observation without knowing." Characteristics with a tendency to deviate from the mean level were emphasized by the knowledge of being observed. The categories of the rating scheme which recorded adaptation in traffic best for both methods and were at the same time most closely related to the personality dimensions were: behavior at intersections; overtaking; and general impression. The results were interpreted as follows: evaluation of driver behavior is not changed when the subject knows he is being observed; and behavior in traffic of adolescent moped drivers depends on attitude and values of the entire personality created by education, in the family and the society.

by Klaus J. Hofner  
Institute for Traffic Psychology of the Traffic Safety Board  
1977 ; 39p  
First published in Zeitschrift für Verkehrsrecht v17 n11 p344-52 (1972) and v17 n12 p376-84 (1972).  
Availability: Reference copy only

HS-018 014

## CONTROL OF SNOWMOBILE NOISE. VOL. 1. TECHNOLOGY AND COST INFORMATION

Existing technology available for reducing noise from individual snowmobile noise sources and the cost of applying this technology to achieve each of three projected noise levels were investigated. The three selected noise levels are: the level typical of currently available, quiet products (80 decibels (dBA) on an A-weighted network at 50 feet); the level of quietest product expected to be available in October 1975 that incorporates the most advanced technology (74 dBA); and a level which is considered to be practically obtainable using available technology by October 1975 (76 dBA). It is suggested that, without relying on new technology, manufacturing firms representing about 60% of the market should have the capability to comply with a 76 dBA level for 1976. Within the engine compartment several noise sources can be quieted, including the engine, the cooling fan, the muffler shell, and the carburetor intake. The use of exhaust systems which utilize an expansion chamber incorporated in a tuned system has eliminated exhaust noise as a major contributor to overall noise. Noise produced by the track and suspension system can only be reduced through design, since baffling techniques are not practical. Although it would seem that the industry's efforts should be directed at reducing operator noise level, techniques for measuring noise at the operator's position are not well defined at this time. Until standard measurement procedures are developed, noise control efforts will have to be directed towards reducing noise levels at 50 feet. The estimated per-machine manufacturing cost increases for noise reduction in snowmobiles, using 82 dBA as a baseline reference, are: 22 dollars for reduction to 80 dBA with an air-cooled engine; 63 dollars for reduction to 74 dBA with a liquid-cooled system; 90 dollars for reduction to 74 dBA with an air-cooled engine; 57 dollars for reduction to 76 dBA with a liquid-cooled system; and 49 dollars for reduction to 76 dBA with an air-cooled system. In general, each decrease to a level below 82 dBA is accompanied by an increase in weight, which may cause further difficulties.

by Bruce A. Davy; Ben H. Sharp  
Wyle Labs  
Contract EPA-68-01-1537  
Rept. No. EPA-550/9-74-003-A ; 1974 ; 63p 13refs  
Availability: NTIS; Environmental Protection Agency, Office of Noise Abatement and Control, Crystal Mall 02, 1921 Jefferson Davis Hwy., Arlington, Va. 22202

HS-018 015

## MVMA NATIONAL FUEL SURVEY. 1974-1975 SUMMARY AND TRENDS

The results of the Motor Vehicle Manufacturers Association's National Fuel Survey, conducted by the Southwest Research Institute, are summarized. The survey was conducted from the summer of 1974 through the spring of 1975. About 550 samples were obtained from 192 marketers and tested during each season. Gasoline, including no-lead gasoline, was found to be plentiful and readily available in all 23 cities surveyed. Data presented on premium grade leaded gasoline shows a decrease in average octane numbers and a rapid increase in lead content for the summer season, with a subsequent decrease for the winter samples. Sulfur content tapered off and decreased slightly compared to the previous year, but it is still higher than the average for 1972 summer premium gasolines. The trends for regular grade gasoline are very similar to the premium gasolines, except for a slight increase in sulfur content in the summer samples. A subsequent decline in sulfur values for the winter season corresponds to what was observed for the 1973 to 1974 season. Tests included distillation, R V P, V/L (calc), specific gravity, lead, sulfur, potassium, trace metals, F I A (Federal Internation of Automobiles), octane number, and existent gum. Considerable data from these tests are presented.

by Ronald M. Estefan  
Southwest Res. Inst.  
1977 ; 56p  
Prepared for the Motor Vehicle Manufacturers Assoc. of the United States, Inc., 320 New Center Bldg., Detroit, Mich. 48202.  
Availability: Motor Vehicle Manufacturers Assoc. of the United States, Inc., 320 New Center Bldg., Detroit, Mich. 48202

HS-018 016

## THE VOICE OF THE TRANSPORTATION CONSUMER. A REPORT TO THE SECRETARY OF TRANSPORTATION ON NATIONWIDE CONSUMER PUBLIC HEARINGS CONDUCTED BY THE OFFICE OF CONSUMER AFFAIRS

The Office of Consumer Affairs of the U.S. Department of Transportation (DOT) conducted a series of fact-finding consumer public hearings throughout the United States between October 1971 and February 1974. Hearings were held in 34 cities and towns located in 21 States. Locations were selected with the objective of reaching the largest cross-section of the American public with varying transportation needs and concerns. Transcripts of the testimony presented at the hearings and the 1,280 questionnaires completed by participants are analyzed. Consumer attitudes on the following transportation intermodal concerns are reported and analyzed: balanced transportation; citizen participation in transportation planning; transportation problems of the elderly and handicapped; ener-

gy; environment; rural transportation; technology; and such special concerns as animals in transit, carpooling, hitchhiking, and motor homes. In addition, material from the hearings and questionnaires which relates to the following specific transportation modes is presented separately: automobile, aviation, bus, motorcycle, bicycles, highways, pedestrians, railroads, rapid transit, trucks, and water transportation. The hearings achieved the following results: determination of consumer concerns; projection of DOT concern for consumer problems; and increased effectiveness of the DOT Office of Consumer Affairs. In addition, the Department has made significant progress in addressing the following particular needs expressed by consumers: accessible public transportation for the elderly and handicapped; flexible use of the Highway Trust Fund; increased funds for mass transit purposes, including operating subsidies; and better guidelines for consumer involvement in transportation planning.

Department of Transportation, Office of Consumer Affairs,  
Washington, D.C. 20590  
1975 : 664p  
Report for 1971-1974.  
Availability: NTIS as PB-241 765, \$15.25

HS-018 017

# **THE VOICE OF THE TRANSPORTATION CONSUMER. A REPORT TO THE SECRETARY OF TRANSPORTATION ON NATIONWIDE CONSUMER PUBLIC HEARINGS CONDUCTED BY THE OFFICE OF CONSUMER AFFAIRS. EXECUTIVE SUMMARY**

The findings of 54 consumer public hearings, held in 34 cities and towns in 21 states for the purpose of learning of consumer transportation needs first-hand, analyzing them, and providing information to the decision makers at the Department of Transportation, are reported. Consumer public hearing testimony and questionnaire responses on the following concerns are discussed: transportation intermodal concerns (balanced transportation, citizen participation in transportation planning, the elderly and handicapped, energy, environment, rural transportation, technology and other special concerns); and transportation modes (automobile, aviation, bicycles, bus, highways, motorcycles, pedestrians, rail, rapid transit, trucks, and water transportation). Important findings include the following: there was a strong desire for a balanced transportation system with greater emphasis on convenient, efficient, economical mass transportation and reduced emphasis on automobile travel and highway construction; among the most vocal participants were the elderly and handicapped who turned out in large numbers, many representing local or national groups; there was also strong concern for the transportation needs of innercity residents, the low income, the poor and minorities; and there were calls for more involvement of minorities in planning and management of transit systems and in contract bidding. It was also found that there was strong advocacy for using Highway Trust Fund money for urban mass transportation and improved rural transportation as well as support for converting the Highway Trust Fund into a general transportation fund; consumers reported dissatisfaction with the widespread problem of inadequate and frequent auto repairs as well as concern for improved driver training and testing, stricter enforcement of laws and insurance reform; many advocated that bicycle pathways be integrated into metropolitan and regional transportation systems; misplaced and damaged baggage were major concerns of air passengers;

Department of Transportation, Office of Consumer Affairs,  
Washington, D.C. 20590  
1975 : 118p  
Report for 1971-1974.  
Availability: NTIS as PB-241 764, \$5.25

HS-018 018

## **ACCIDENT CAUSATION AND ACCIDENT AVOIDANCE: METHODOLOGICAL APPROACHES. INTRODUCTION AND SYSTEMS OVERVIEW**

An overview of systems that describe the factors which occur prior to automobile crashes, especially those that are instrumental in or related to the initiation of a collision, is given. Four causal models are presented: the Indiana Accident Causal Taxonomy; a descriptive model of the Accident Generation Process by Calspan; the Human Factors Causal System; and the Miami Causal Model for Single Vehicle Accidents. The Indiana model is a logical breakdown of individual factors into four basic categories: human direct causes; human conditions and states; vehicular factors; and environmental factors. Each of these, in turn, has been broken down into sub-levels. When all levels are presented, they are assessed for features which lead to an accident. The Accident Generation Process attempts to structure and code in a meaningful way, the sequence of events which culminate in a crash. It is a descriptive model of what precrash events occur, and how they relate to each other in order to characterize the failure or failures which caused the crash. In this model, each vehicle in a collision is treated as the subject vehicle. The last two models are based upon human factors, cause and effect relationship, the effect being the primary human failure leading directly to the collision situation, and the cause being the reasons for the human failure. Human factors parts of the model consist of an event sequence involving information failures; a crash occurrence, involving the type of collision; and the severity of the crash. The Indiana Accident Avoidance methodology shows the greatest use for future models in accident investigation research.

by James C. Fell  
National Hwy. Traffic Safety Administration  
1975 : 21p 18refs  
Presented at the Motor Vehicle Collision Investigation  
Symposium, Buffalo, N.Y., 6-10 Oct 1975.  
Availability: Reference copy only

HS-018 019

## **AN EVALUATION OF THE OFFICIAL SWEDISH STATISTICS ON SERIOUSLY INJURED IN ROAD TRAFFIC ACCIDENTS**

Available hospital and traffic accident statistics regarding 2,689 people seriously injured in traffic accidents in 1966 in the Uppsala, Sweden, hospital region were analyzed. The two sets of statistics were compared, primarily on the basis of dates and birth registration numbers. It was found that: only 32% of the category "seriously injured" in traffic accidents were correctly registered as such in the official traffic accident statistics; 25% were wrongly registered as "slightly injured"; one-half of the seriously injured were not registered at all constituting a drop-out which contributes to biased statistics; and false registration is primarily associated with short-term hospitalization and absence of surgical operations during the

traffic accident statistics or defined, present patient statistics be used as one source in order to assess the magnitude of the problem; and samples from it be investigated to elucidate special conditions of interest from the preventive point of view. The advantages of sampling versus total studies, especially if the latter are incomplete, are seen to be pertinent to the present situation: less risk of bias; lower costs; better quality of observation; and rapidly obtained results.

by Jens Sande; Jan Thorson

Publ: Scandanavian Journal of Social Medicine v3 n1 p5-11 (1975)

1975 ; 21refs

A preliminary report was presented at the 3rd International Congress for Traffic Medicine, New York, 1969.

Availability: See publication; Jan Thorson, Nockebyavagen 9, S-161 40 Bromma, Sweden

HS-018 020

## COMPONENT DEVELOPMENT OF AUTOMOTIVE RECIPROCATING STEAM EXPANDERS

The progress to date on the development of a reciprocating steam expander component for the Closed Rankine cycle steam powerplant is summarized. The principal components reviewed are: pistons, ring/liner combinations, valve train, series poppet valves for variable admission of steam to the cylinders and recompression steam relief valve. The current state of the art of automotive technology was used in component development work. Temperature and pressure measurement techniques are also described. Development testing for 350 hours was accumulated on a V-4 expander, attaining 26 horsepower per cylinder, with modified four cycle diesel pistons. The feasibility of crankcase splash lubrication using a mineral oil with the proper additives was demonstrated. A single cylinder expander was used for preliminary investigation of series poppet valves and demonstrated 40.5 horsepower per cylinder loads with palm-bearing pistons. A total of 1500 hours of component development testing has been completed on this engine. The in-line four cylinder expander, specifically designed as a Rankine cycle engine, was used for over 600 hours in component and system development testing. All three expanders have demonstrated water rates below 10 pounds per horsepower-hour with 1000 psia per 1000° F steam. Drawings of each expander and photographs of component parts are provided.

by Stanislav Jakuba; James A. McGeehan  
Scientific Energy Systems Corp.

Rept. No. SAE-750068 ; 1975 ; 16p 7refs

Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.

Availability: SAE

HS-018 021

## AN ATTEMPT TO DEFINE THE TOLERANCE OF THE HEAD OF YOUNG CHILDREN TO SHOCKS [ESSAI DE DEFINITION DE LA TOLERANCE DE LA TETE DES JEUNES ENFANTS AUX CHOCs]

An application of dimensional analysis to determine the tolerance of the heads of three and six-year-old children to automobile accident deceleration and impact is presented using the physical parameters of impacts to the heads of other subjects (squirrel, monkey, cynomolgus, 10 and 20 pound rhesus

monkeys, chimpanzee, and adult man) for which the results are known. It is concluded that: the attempt to determine the impact tolerances of children's heads can be improved in various ways, in particular by tests on animals, especially young animals with uncompleted ossification; and the impact tolerances for the heads of six-year-old children appear to be in the neighborhood of adult minima.

by A. Fayon; C. Tarrere

Peugeot-Renault Assoc., Physiology and Biomechanics Lab. 1976 ; 10p 8refs

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p252-9. Text also in French.

Availability: Reference copy only

HS-018 022

## RESEARCH ON THE DESIGN OF CHILD RESTRAINT SYSTEMS WITH AN ANIMAL MODEL [RECHERCHE SUR LA CONCEPTION DE SYSTEMES DE RETENTION D'ENFANTS A L'AIDE D'UN MODELE ANIMAL]

Dynamic tests of child restraints were carried out using a baboon as test subject so that major biomechanical criteria for assessing present restraint systems might be studied and elements that might improve the systems be pinpointed. Crashes were simulated in the frontal mode at 30 and 50 kilometers per hour on a sled carrying the occupant department of a medium-sized vehicle. Mean decelerations were 17 and 24 g. Five child seats were chosen for testing according to type of restraint (helmet with harness, support surface) and type of anchoring (number of anchor points, shock absorption). It was found that: the movement of the chest does not seem to involve a dangerous phase; the impact shield system seems to be of doubtful value because of the thoracic or abdominal impact it produces; submarining is best avoided with the five-point harness seats; it appears that it is possible to obtain correct shock absorption with a few types of harness seats, but to the detriment of displacement; and the notion of available space must be reconciled with that of shock absorption. Drawings of each seat tested and force graphs of the tests are provided.

by M. Dejeammes; R. Quincy

National Hwy. Safety Organization, Bron-France Crash Lab. 1976 ; 18p

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p260-77. Text also in French.

Availability: Reference copy only

HS-018 023

## STATISTICAL STUDY OF 183 CASES OF CHILDREN INJURED IN ACCIDENTS WHILE RIDING IN THE REAR OF A MOTOR VEHICLE [ETUDE STATISTIQUE A PROPOS DE 183 CAS D'ENFANTS ACCIDENTES APRES AVOIR PRIS PLACE A L'ARRIERE D'UN VEHICULE AUTOMOBILE]

A total of 183 cases of children hospitalized at a French hospital (1957-1973) due to automobile accident injuries sustained while the child was riding in the rear seat of the vehicle are examined. Injury types, locations, numbers, and seriousness are discussed. Little accident and injury causation

information was available. It is concluded that: injuries incurred in car accidents by children placed in the rear seat and not restrained properly are very frequent; and these accidents often result in multiple severe injuries, with cranial traumas and severe limb injuries in particular often occurring together. Apart from a few fatalities, many children have been left with anatomical or functional after-effects, which in most cases could have been minimized or avoided by an appropriate restraint system.

by M. Fournier; M. Cisterne  
Clermont-Ferrand  
1976; 6p

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p246-51. Text also in French.

Availability: Reference copy only.

HS-018 024

**CHILD RESTRAINT DEVICES IN VEHICLES:  
ANALYSIS AND EVALUATION OF VARIOUS  
SYSTEMS [DISPOSITIFS DE RETENUE DES  
ENFANTS A BORD DES VEHICULES--ANALYSE ET  
EVALUATION DES DIFFERENTS SYSTEMES]**

The effectiveness of various restraint devices in the automobile is compared and evaluated without determining whether the thresholds of children's tolerance were reached or exceeded. A three-year-old child test dummy was sled tested to determine head and chest decelerations along three axes, trajectories and maximum displacements of the child (using high speed films), and head severity indices and modules of maximum chest acceleration at three millisecond intervals. Harnesses, bucket seats, and impact shield devices were evaluated. None of the devices tested offers adequate protection to children during violent crashes, some may even be dangerous. Minor modifications would improve some devices; some are simply inadequately designed. It is natural to have bad results: few child restraint devices have been subjected to serious dynamic tests in vehicles and the limits of children's biomechanical tolerance are poorly understood at present. More specific testing is being undertaken.

by G. Oberle; G. Mauron; C. Tarrriere  
Peugeot, Paris Res. Center; Peugeot-Renault, Physiology and Biomechanics Lab.  
1976?; 13p 9refs

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p301-13. Text also in French.

Availability: Reference copy only

HS-018 025

**ACCEPTABLE DISPLACEMENT OF RESTRAINED  
CHILDREN IN FRONTAL IMPACTS: VALIDITY OF  
THIS CRITERION AS A PROTECTION CRITERION  
[DEPLACEMENT ADMISSIBLE EN CHOC FRONTAL  
POUR LES ENFANTS RETENUS: VALIDITE DE CE  
CRITERE PRIS COMME CRITERE DE  
PROTECTION]**

An examination of the validity of a maximum displacement criterion as a criterion of protection in frontal impact for

restrained children is presented. The examination was in two stages: establishment of an acceptable maximum displacement for restrained child dummies; and an experimental study of its validity as a criterion of restraint device performance. In all tests, the restraint device used was a harness. It was found that the application of the displacement criterion used for adults in the United States did not allow the optimal use of available space for deceleration of children during a violent impact. It was also demonstrated that the maximum displacement criterion used in isolation did not constitute an adequate protection criterion. Such a criterion resulted in restraint devices of mediocre actual performance. In the tests presented, the performances turned out to be mediocre because of the use of an unrealistic deceleration curve (with a displacement of 400 millimeters), and that this state of affairs could be significantly improved by the use of more realistic deceleration curves, with a greater displacement of the test sled. A possible recommendation is made for a parachutist type of harness which would simultaneously support the chest and pelvis of a child by two pelvic straps at the level of the thighs. Chest straps should have a minimal width of 50 millimeters.

by D. de Rosa; A. Fayon; C. Tarrriere; G. Mauron  
Renault Res. Dept.; Peugeot-Renault Assoc. Physiology and Biomechanics Lab.; Peugeot Paris Res. Center  
1976; 10p 5refs

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p314-22. Text also in French.

Availability: Reference copy only

HS-018 026

**STATISTICAL AND CLINICAL STUDY DEFINING  
THE TYPOLOGY OF TRAFFIC AND TRAFFIC-  
RELATED ACCIDENTS TO CHILDREN [ETUDE  
STATISTIQUE ET CLINIQUE PRECISANT LA  
TYPOLOGIE D'ACCIDENTS D'ENFANTS-  
ACCIDENTS DE CIRCULATION ET APPARENTES]**

A study of child involvement in accidents is presented. The study presented included two facets: an estimate of the distribution of various categories of patients, involving 96 accident victims between the ages of 0-18; and a study of three major categories of accidents, including pedestrian, automobile passenger, and operators of bicycles. The larger number of accident victims occurred in the age groups from 0-15 years. Examination of medical records show that children knocked down by motor vehicles primarily show head injuries, and secondarily show injuries of the lower extremities. Position of vehicle in child accident cases was also noted. In conclusion, it was found that approximately 25 percent of accidents occurring in childhood are traffic or related accidents. If morbidity is high, mortality by type of accident is likewise high. One investigation determined that 80 percent of accidental deaths are traffic accidents. In the sample as a whole, 2 percent of the subjects died within the first 24 hours, a percentage below that for an adult sample. It is suggested, because of the frequency and severity of cranial injuries in children, that it is necessary to forbid children from occupying front seats, and insofar as possible, to keep them in back seats by means of a retention system; and for users of two-wheeled vehicles, habitual wearing of a helmet to reduce cranial injuries.

by M. Ramet; D. Cesari  
National Hwy. Safety Agency, Bron, France  
1976; 13p

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p101-15. Text also in French.

Availability: Reference copy only

HS-018 027

**STUDY OF THE DYNAMIC BEHAVIOR OF THE HEAD-NECK SYSTEM IN CHILDREN AGED 9-11 WHEN LOW AMPLITUDE SINUSOIDAL FORCES ARE APPLIED [ETUDE DU COMPORTEMENT DYNAMIQUE DU SYSTEME TETE-COU LORS DE L'APPLICATION DE FORCES SINUSOIDALES DE FAIBLE AMPLITUDE CHEZ L'ENFANT AGE DE 9 A 11 ANS]**

The behavior of various body links, and of all body segments in the head-neck system of small children was studied, in order to devise a system of seatbelts adapted to the size-characteristics of children. Children between the ages of 9-11 were chosen, seated on an adjustable seat and firmly held by a shoulder harness. The forearm and head were then tested. Displacement was measured by means of a potentiometer and displayed on the screen of a cathode ray oscilloscope. Subjects exerted their strength against a dynamometer by means of a strap around the head or around the wrist. The dynamic behavior of the two body systems of the child were found to follow the same laws as those of the adult when low amplitude forces were applied. However, muscular strength was well below that of an adult, and when the body was brutally decelerated, the musculature necessary to counterbalance the forces of inertia were proportionately much greater than in the adult-activated at the level of the head. Thus, the role of musculature in absorbing energy, is limited. It is essential, therefore, to limit as much as possible the strains on the head-thorax bond by not subjecting the head to excessively brutal deceleration by stringent restraint of the thorax.

by J. P. Verriest  
ONSER, Shock Lab., Lyon, France  
1976?; 19p refs

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p216-36. Text also in French.

Availability: Reference copy only

HS-018 028

**BIOKINETICS OF CRANIOCEREBRAL IMPACT ON CHILDREN: ANATOMICAL-CLINICAL CONCLUSIONS FROM 200 CASES OF HIGHWAY ACCIDENT TRAUMATISM. (LA BIOCHINETIQUE DE L'IMPACT CRANIOCEREBRAL CHEZ L'ENFANT. DEDUCTIONS ANATOMO-CLINIQUES SUR 200 TRAUMATISMES ROUTIERS)**

Two groups of children were compared in an attempt to detect the particularities linked to the biokinetics of craniocerebral

at a neurosurgical clinic in Rumania following accidents, eight of whom were injured as occupants of a vehicle and 92 as pedestrians. The second group consists of 100 children who died following traffic accidents and for whom craniocerebral traumatism was the sole or a contributory cause of death. Of the 100 children hospitalized, 74 left the hospital cured, 13 improved, three were unchanged, one was in an aggravated condition, and nine were cases of multiple traumatization resulting in death. Of the children in the second group, 86 were pedestrians and 14 were passengers in a vehicle involved in an accident. In both groups, over 60% of the children were male. While automobiles caused most of the injuries to children in the first group, trucks were involved in 87 of the fatal accidents. No correlation was found between traumatism intensity, cranial lesions, and cerebral lesions among children. Although clinically there was more frequent occurrence of cerebral contusion and more rarely edema and cerebral dilaceration, in fatal craniocerebral traumatisms it is dilaceration which predominates, followed in frequency by contusion. While no indications to justify an assumption of a backlash injury were found at the clinic, the autopsies showed a contusion or dilaceration resulting from backlash in 23% of the cases. Lesions of the cerebellum or cerebral column were frequently found during autopsies, but clinical examination did not locate signs of posterior fossa injury. In the context of craniocerebral traumatism, associated lesions (multiple traumatisms) represent a major aggravation factor, accounting for all nine fatalities in the clinical group and being present in 77% of the fatally injured children.

by N. Obu; M. Rusu; Aurore Stanciu; C. Aldescu; G. Scripcaru; N. Janovici  
Jassy Neurosurgical Clinic; Jassy Medicolegal Inst., Rumania  
1976; 10p 21refs

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p50-8. Text also in French.

Availability: Reference copy only

HS-018 029

**STATISTICAL STUDY OF ACCIDENTS TO CHILDREN UP TO AGE 14 OBSERVED AT THE SALON-DE-PROVENCE HOSPITAL [ETUDE STATISTIQUE SUR LES ACCIDENTS CHEZ LES ENFANTS DE 0 A 14 ANS A L'HOPITAL DE SALON-DE-PROVENCE]**

A statistical study was conducted to define the frequency of lesions and the number of victims up to 14 years of age among a population of traffic accident casualties observed in a homogeneous manner at the Salon-de-Provence Hospital Center in Salon, France. The Salon hospital has operated a medically trained pickup and revival unit for highway accident casualties since 1957, enabling injured persons to be seen at the site, observed and treated during transportation to the hospital and followed up at the hospital by the same medical team. During the period January 1973 to July 1974, 10.5% of the 1,619 accident victims were children. Data on the injuries show that: the maximum danger of injury to children as pedestrians occurs from ages 3 to 9; for children cyclists, there is a peak at age 4 to 5 and a summit at age 13 to 14; and as passengers in vehicles, the most dangerous ages are from 1 to 4 years and from 13 to 14 years. Data on cranial lesions in-

losses of consciousness and lacerations are rarer for children. In addition, children under age 7 are much more exposed to cranial injury than older children (45% as compared to 33%). Facial lesions are less than half as common in children as in the total accident victim population, and thoracic lesions occur in children only about 25% as often as in all victims. Abdominal and pelvic lesions are slightly more common in children than in all victims, while lesions of the rachis and upper members are significantly less. Fractures and lesions of the soft tissues of the lower members are 48% for children and 65% for all victims. 14Reference copy only

by Bourret; Gazin; Cavallero

1976 ; 10p

Unofficial translation from Proceedings of the International Meeting on Biomechanics of Trauma in Children, Lyons, France, 17-19 Sep 1974, n.p., n.d., p30-1--30-8. Text also in French.

HS-018 030

## ENERGY STATISTICS. A SUPPLEMENT TO THE SUMMARY OF NATIONAL TRANSPORTATION STATISTICS. FINAL REPORT

Selected time-series data describing the transportation, production, processing, and consumption of energy for the United States (U.S.) are presented. Financial, inventory and activity statistics related to the transportation of energy commodities via pipeline, water, truck, and rail for periods varying from the past 40 years to the past several years are included. Estimates of U.S. proved crude oil reserves and time-series (for as far back as 1918) on natural gas reserves and production, and U.S. refinery capacity and yields are given. Statistics on uranium resources and reserves by state, water power by geographic division (1945-1973), and electric power generating capacity (1900-1974) are provided. Estimates of the fuel and oil costs for the various modes of transportation based on fuel production and sales data, transportation fuel consumption data disaggregated by mode, and 1972 fuel and energy statistics (production, consumption, and processing) for the nine regions of the U.S. are also presented. The consumption statistics for the various modes cover periods as long as 1940-1974.

by William F. Gay

Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142

Contract OP517

Rept. No. DOT-TSC-OST-75-33 ; 1975 ; 163p refs

Report for 1961-1974.

Availability: GPO

HS-018 031

## SPARK PLUGS--HOW TO KEEP THEM SPARKING

Proper automotive spark plug maintenance procedures are discussed: removing the plugs, inspecting and cleaning the plugs, setting the gap, installing and selecting plugs, and finding the fouled plug. Illustrations of spark plug gaps and different types of fouling (with possible explanations), the charted relationship between plug and cylinder head and proper torque, and a listing of plug-changing tool costs are provided.

by Miles Schofield

Publ: Popular Science v208 n1 p96-9 (Jan 1976)

1976

Availability: See publication

HS-018 032

## A SURVEY OF AUTOMOTIVE RANKINE CYCLE COMBUSTION TECHNOLOGY

What is now known about the design of Rankine cycle combustors for automotive application is described. The operation of the Rankine cycle powerplant is briefly reviewed and the role of the combustion subsystem is placed in perspective. The design requirements for the combustor subsystem is discussed and experimental results from a number of development programs are presented: the Alternative Automotive Power Systems Program conducted by the Federal government; and programs in private industry conducted by General Motors, the Williams Engine Company, and the Carter Engine Company. Graphs and tabulations of the results are provided, comparisons are made, and the significance of the results is discussed.

by S. Luchter; W. Mirsky

Environmental Protection Agency; University of Michigan

Rept. No. SAE-750067 ; 1975 ; 13p 27refs

Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.

Availability: SAE

HS-018 033

## STEAM POWER SYSTEMS' CALIFORNIA CLEAN CAR PROJECT

Performance test results for a low-pollution, steam-powered automobile using a reciprocal piston expander built for the California Clean Car Project are presented. The emissions test (conducted on a dynamometer) consisted of a cold startup, 1372 seconds of stop and go driving, a 10 minute shutdown, a hot restart, and another 505 seconds of stop and go driving. Three emissions sample bags were taken. Steady state exhaust emissions were measured on the dynamometer at speeds of 20-50 mph. Various fuel mileage tests were run: a 7.5 mile urban and a 10 mile, 45-60 mph driving cycle; steady-state dynamometer and highway tests. Other tests included: noise level tests (drive-by tests at 30-35 mph and idling tests, both compared to the performance of a 1972 Chevrolet Vega station wagon); dynamometer grade-climbing tests at 60 mph down to 30 mph; acceleration tests on level streets; top speed tests; startup time tests; and tests with alternative fuels (methanol and Utah Light Hydrotreated Oil). The reliability and general driveability, the powerplant component performance, and future improvements for the vehicle are discussed. The vehicle demonstrated the potential of the Rankine cycle engine to produce very low exhaust emissions over the Federal driving cycle. The car is also quiet and met the project goals for grade-climbing and top speed. Fuel mileage and acceleration test results did not meet the project goals, but they can be improved enough to exceed the goals with a one-year improvement program.

by Philip H. Schneider

Steam Power Systems, Inc.

Rept. No. SAE-750070 ; 1975 ; 11p 12refs

Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.

Availability: SAE



HS-018 034

**EXPERIENCE WITH STEAM CARS IN CALIFORNIA**

The development and testing of two steam propulsion systems in California which were installed into sub-compact cars suitable for urban driving are discussed. The Aerojet Liquid Rocket Company installed a steam turbine in a Chevrolet Vega, while Steam Power Systems built a piston engine system for a car of special design. Photographs of the vehicles and diagrams of the propulsion systems are provided. Vehicles were subjected to: steady-state and Federal Urban Driving Cycle emissions tests on a chassis dynamometer; road performance tests; Urban Driving Cycle, Federal Highway Driving Cycle, steady-state dynamometer, and steady-state two way level road tests for fuel economy; and exterior drive-by, idle, and interior passenger compartment sound level tests. It was demonstrated that it is possible to reduce exhaust emission levels to less than those required by the 1978 Federal standards. Road performance was adequate for urban-suburban driving. Fuel consumption was higher than comparable internal combustion-powered vehicles. Guidelines for future improvements are given.

by Roy A. Renner; Michael Wenstrom  
Rept. No. SAE-750069 ; 1975 ; 14p 17refs  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-018 035

**HEAD IMPACT RESPONSE**

The response of the human head to short duration impacts of varying magnitudes and directions was determined by dropping seven intact embalmed cadavers onto 60-durometer, 90-durometer, and rigid surfaces. Drops were also made with the head decapitated. Impacts with seven fresh cadavers were made to compare with the embalmed head response. Accelerometers, load cells, and force transducers were used for measurement purposes. It was found that: the skull acceleration response approximated rigid body motion for the 60-durometer surface impact but localized accelerations increased for the 90-durometer, rigid and glass surfaces; satisfactory repeatability for skull accelerations could only be obtained for impacts against the 60-durometer surface; it was possible to establish a linear normalizing relationship for dummy heads based on the 60-durometer drops only; changes in skin thickness and moisture content were very influential on head response; the response of the head to glass surface impacts causing glass breakage was different for the intact and decapitated conditions; fresh versus embalmed cadaver head acceleration response comparisons on the same cadavers were unsuccessful because the embalming procedure grossly distorted the soft tissue of the cadavers; an investigation of the effect of skin thickness on head acceleration response in the cadaver was unsuccessful (results of varying the thickness of the best skin substitute found are given); and skin damage between the initial intact cadaver and decapitated head tests changed the head acceleration response to stiff impact too much to permit recommendation of reliable free head certification performance criteria.

by Voight R. Hodgson; L. M. Thomas  
Wayne State Univ., Dept. of Neurosurgery, Detroit, Mich.  
Rept. No. VRI-7.2 ; 1975 ; 179p 8refs  
Availability: SAE

HS-018 036

**THE GOVERNMENT'S ROLE IN AUTOMOTIVE QUALITY**

The role the Federal government in automotive quality, through the Office of Defects Investigation (ODI) of the National Highway Traffic Safety Administration, is discussed. The ODI investigates reports that suggest significant safety defects involving groups of vehicles where the defect is not the subject of a Federal standard. Investigations encompass the entire production process from design, material, manufacturing to quality control. The ODI organization and general operation are explained.

by Andrew G. Detrick  
National Hwy. Traffic Safety Administration  
Rept. No. SAE-750031 ; 1975 ; 8p  
Presented at the Automotive Engineering Congress and  
Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-018 037

**INJURY PATTERNS IN TRAFFIC ACCIDENTS AND SUGGESTED PREVENTIVE MEASURES**

A short survey is given of the main patterns of injuries sustained in traffic accidents. Various injury circumstances are discussed: head-on collisions (driver and front-seat passenger); side collisions; rear-end collisions; and injuries to unprotected road users. The following injuries are accounted for: ruptures of the parasagittal bridging veins and gliding contusions of the brain, axis fractures, and aortic and pelvic injuries.

by Gerhard E. Voigt  
Publ: Acta Orthopaedica Scandinavica, v46 n3 p475-83 (Jun 1975)  
1975 ; 20refs  
Availability: See publication

HS-018 038

**THE ALCOHOL IMPAIRED DRIVER**

The role of alcohol in traffic accidents is examined, and the literature as it relates to the effect of alcohol on driving skills is reviewed. The specific effects of alcohol on risk-taking behavior, attention, tracking, reaction time, visual acuity, and visual fields are discussed. The hangover effect is also considered. Engineering implications are examined; engineers are responsible for maintaining uniformity in road design, minimizing the rate at which decisions have to be made, and providing road shoulders that allow as much room as possible for straying from the road itself.

by J. E. Sandersen  
Ministry of Transport, Road Transport Div., Wellington, N.Z.  
Rept. No. Traffic-RR-14 ; 1975 ; 15p 46refs  
Presented to the New Zealand Roading Symposium, Aug 1975.  
Availability: Traffic Research Section, Road Transport  
Division, Ministry of Transport, Private Bag, Wellington, N.Z.

HSL-018 039

## REGULATIONS AND ENFORCEMENT [TRAFFIC SAFETY]

The roles that traffic rules and their enforcement can reasonably be expected to play in the field of traffic safety are reviewed. The following topics are considered: driving skills (manipulation skill, conflict and anticipation skill); traffic regulation types (safe practice, uniform practice, and combination rules); conflict of safety and uniformity (lane driving and right turns); education of drivers; enforcement (limited enforcement resources and enforcement demands of regulations); recent experience in New Zealand ("blitz" enforcement campaigns, the fuel crisis, and seat belt wearing laws); public acceptance (self-enforcing devices, devices requiring enforcement, over use of devices); and enforcement integration. Enforcement and traffic rules must be seen as parts of an integrated whole if they are to be used to maximum effectiveness.

by M. R. Palmer

Ministry of Transport, Traffic Engineering Section, Private Bag, Wellington, N.Z.

Rept. No. Traffic-RR-15; 1975; 15p

Presented to the New Zealand Road Symposium, Aug 1975.

Availability: Corporate author

HSL-018 040

## TRAFFIC ACCIDENT TRENDS AND PATTERNS

The trends and patterns of injury traffic accidents in New Zealand over the last two decades are traced and described through tables, graphs and comments. The following factors are considered in an examination of the trends: accident rates (level of motorization, and casualty rates); accident severity; road user type (driver and passengers, cyclists, motorcyclists, and pedestrians); urban-rural distribution; night accidents; ages of injured road user (by type); accidents by day and by time of day; accident type; factors influencing trends; 1974 accident data; and predictions for the future. Significant trends include: a general increase in accidents of about 6% per year, about the same as vehicle registrations and fuel consumption but greater than the population increase; a slight decline in the number of accidents per vehicle mile; a doubling in the number of vehicles per person; a dramatic increase in the number of motorcycle casualties; the increase in urban accidents has not been as great proportionally as the growth in urban population; night accidents increased; a marked trend towards greater involvement of younger age groups in traffic accidents; and a notable change in the time of day of accidents after hotel business hours were extended in 1967.

by J. B. Toomath

Ministry of Transport, Traffic Res. Section, Private Bag, Wellington, N.Z.

Rept. No. Traffic-RR-16; 1975; 18p 18refs

Presented to the New Zealand Road Symposium, Aug 1975.

Availability: Corporate author

HSL-018 041

## SINGLE-CAR ACCIDENTS

Causes and remedies of single-car accidents are discussed. The relationships of carelessness, alcohol and other drugs, fatigue, highway hypnosis, emotional factors, and mechanical defects to these accidents are considered and countermeasures are suggested.

Publ: Driver v9 n6 p1, 3-7 (Nov 1975)

1975

Availability: See publication

HSL-018 042

## CAVEAT VIATOR: THE DUTY TO WEAR SEAT BELTS UNDER COMPARATIVE NEGLIGENCE LAW

An argument is presented in favor of a comparative negligence law with respect to the use or non-use of seat belts to be applied to traffic accident injury damage suits. The effect of seat belt use on the outcome of traffic accidents is discussed. The implications, considerations, and possibilities of mandatory seat belt legislation are examined. The concept of comparative negligence is fully explained and applications of the concept to specific factual situations are provided.

by John A. Hoglund; A. Peter Parsons

Publ: Washington Law Review v50 n1 p1-27 (Nov 1974)

1974; 95refs

Availability: See publication

HSL-018 043

## THE CERAMIC ENGINE PREPARES FOR TAKE OFF

The developmental efforts and advantages of gas turbine engines constructed of ceramics (silicon carbide or silicon nitride) are discussed. Ceramic engines demonstrate much less thermal expansion, are lighter, cheaper, and easier to design and construct than modern metal alloy turbine engines. Ceramic components would give the gas turbine a fuel consumption as good as a diesel engine and better than a 1970 gasoline engine.

by Nicholas Valery

Publ: New Scientist v67 n967 p634-6 (18 Sep 1975)

1975

Availability: See publication

HSL-018 044

## SPECIAL REPORT TO THE U.S. CONGRESS ON ALCOHOL AND HEALTH (2ND) FROM THE SECRETARY OF H.E.W. JUNE 1974. CHAP. 6, ALCOHOL AND HIGHWAY SAFETY

The relationship of alcohol consumption to highway safety is discussed in some detail. The primary source of evidence of alcohol involvement in a traffic accident is the blood alcohol concentration (BAC) in the body. The distribution and level of BAC in different groups and situations are discussed: the driving population; clear-record drivers; nonfatal crashes; fatal crashes; drivers convicted of driving while intoxicated; and pedestrian fatalities. Other alcohol-accident factors considered include: crash probability and BAC; personal characteristics (crashes, and alcohol); biographical variables (sex, age, marital status, and occupation); driving variables (previous crashes, driving convictions, and license suspensions); drinking variables; and countermeasure programs. It was found that most people killed in traffic accidents after drinking, as well as most convicted of DWI, have very high BAC, averaging about twice the level considered legally impairing.

Department of Health, Education, and Welfare, Washington, D.C.  
1974 ; 12p 48refs  
Availability: Corporate author

HS-018 045

### **ALCOHOL PROLONGS TIME COURSE OF GLARE RECOVERY**

Nine male subjects (aged 20-28) participated in a replicated 3x3 crossover experiment which was run double blind. Two alcohol doses (0.5 and 1.0 milliliter (ml) per kilogram (kg) of body weight) and a placebo were used. Alcohol in the form of 95% ethanol was diluted with fruit juice so that the total volume (ml) was three times the subject's body weight (kg). Twenty minutes were allowed for the consumption of the drink. Blood alcohol concentration (BAC) was estimated before drinking and at different intervals afterward using a breathalyzer. It was found that the time course of adaptation following a 10 second exposure to a uniform bright field of light is significantly retarded after alcohol ingestion. Graphs are provided which illustrate: the time course of adaptation for placebo and alcohol 90 minutes after drinking; group mean recovery times as a function of time after drinking; mean recovery time to targets of five contrasts as a function of blood alcohol level; and recovery times to five different contrasts as a function of time after alcohol. These delays in glare recovery are believed to be occurring at the retinal level. They have been demonstrated at very low BAC's (approximately one cocktail on an empty stomach) and are dose related. The luminance parameters of the testing are similar to the luminance levels sometimes encountered in actual driving.

by Anthony J. Adams; Brian Brown  
Publ: Nature v257 n5527 p481-3 (Oct 9 1975)  
1975 ; 9refs.  
Availability: See publication

HS-018 046

### **A STUDY ON TRAFFIC ACCIDENT INVOLVEMENT OF GUAM'S DRIVER EDUCATION STUDENTS**

Sample groups of 100 driver education students and 100 non-driver education students were randomly selected for a study of their traffic accident involvement. Government traffic accident data were checked to determine: the names of students involved in traffic accidents; the number of traffic accidents in which each student was involved; the type of accident; the driver responsible for the given accident; and the estimated damage costs to the vehicles involved. Data pertain only to the period September 1, 1970 through June 30, 1974. It was found that: the likelihood of a driver being involved in a traffic accident was dependent on whether or not the driver had participated in the driver education course; the 100 driver education students had 15 accidents; and the non-driver education group had 35 accidents per 100 drivers.

Guam Office of Hwy. Safety  
1977 ; 2refs  
Availability: Dept. of Public Works, Government of Guam,  
P.O. Box 2950, Agaña, Guam 96910

HS-018 047

### **CORRELATES OF TEST DRIVER MEASUREMENTS AND USER ACCIDENTS. FINAL REPORT**

Changes in test-driver control and vehicle state variables (gas pedal activity, speed, lateral acceleration) with rural unsignalized intersections of different accident histories were investigated to develop models of driver behavior which may explain the relationship with accidents. Eighteen test-drivers each drove a 200-mile route in a Buick sedan, with 30 seconds of data collected prior to 35 rural intersections. Significant differences across intersections existed in most variables measured, but only braking activity primarily discriminated sites of high and low accident histories. In addition, a control model of driver performance was investigated explicitly relating geometrics to driver performance. Sample statistics from a variety of runs at a variety of sites are provided.

by J. B. Neuhardt; R. A. Miller; D. A. Hoffmeister; T. H. Rockwell  
Ohio State Univ., Systems Res. Group, Columbus, Ohio 43210  
1974 ; 94p 13refs  
Prepared on cooperation with the Federal Hwy.  
Administration and the Ohio Dept. of Transportation.  
Availability: Corporate author

HS-018 048

### **TRAFFIC TECHNICIAN TRAINING: THE TENNESSEE EXPERIENCE**

A Tennessee program for the training of traffic engineering technicians is discussed. The program rationale, the training approach and format, and the results of the program are considered. A comparative profile of persons who attended all or part of the program, and evaluation results of specific sessions of curriculum and the overall curriculum by the attendees are provided.

by Frederick J. Wegmann; William J. Grecco; Joseph Philips, Jr.  
Publ: Traffic Engineering v45 n12 p24-7 (Dec 1975)  
1975 ; 4refs  
Availability: See publication

HS-018 049

### **THE DRINKING COP**

The problems, symptoms and characteristics of alcoholism, especially related to policemen with drinking problems are discussed. Methods of approaching, helping, and treating the policeman with a drinking problem are suggested.

by Leon Dishlaccoff  
Publ: The Police Chief v63 n1 p32,34,36,39 (Jan 1976)  
1976  
Availability: See publication

HS-018 050

### **REVERSIBLE FLOW ON A SIX LANE URBAN ARTERIAL**

The characteristics of reversible flow on a six-lane urban arterial street are analyzed in terms of volume, capacity and accidents. Traffic volume counts were made at several locations

by 15-minute periods throughout the day. Capacity and level of service for each of the 12 signalized intersections on the route were determined by collecting the following data: peak hours, approach widths, G/C ratios; and turning movement counts. A review of 817 accident report forms for 1972 provided collision diagrams and written description by which the nature of the facility could be judged a contributor to accidents. It was found that 137 (16.8%) did have a direct relation to the reversible nature of the facility, and that 81% of these 137 accidents related to a left turn being made across a lane designated for flow in the same direction. It is concluded that reversible flow has a high potential to increase a facility's capacity, however the traffic engineer, before implementing the technique, should carefully consider the potential for certain types of accidents.

by Jonathan E. Upchurch

Publ: Traffic Engineering v45 n12 p11-4 (Dec 1975)

1975 ; 10refs

Availability: See publication

HS-018 051

## **DIRECT CONNECTING RAMPS TO AND FROM MAJOR TERMINALS. INFORMATIONAL REPORT**

A study was made of highway ramps connecting full access control freeways to major terminals, with not more than one intermediate connection between the freeway and the terminal. Questionnaires were sent to state governments, foreign agencies, and other appropriate agencies to determine facilities suitable for study, and 61 sites in the United States and foreign countries were selected. General characteristics of these different facilities are discussed. The criteria that must be developed for justifying direct connection ramps relate to four major areas: traffic, safety, social-environmental, and cost effectiveness. The design considerations of direct connecting ramps are considered: planning, location, transition area, reservoir area, and signing and operations. The different categories of interchanges are illustrated and statistical information related to the facilities studied is provided.

Technical Council Com. 5-HH

Publ: Traffic Engineering v45 n12 p32-9 (Dec 1975)

1975

Availability: See publication

HS-018 052

## **WHEN IT BECAME LEGAL TO DRINK AT 18 IN MASSACHUSETTS AND MAINE WHAT HAPPENED?**

Data on fatal crash involvement in Massachusetts and Maine after the legal drinking ages in both states were lowered to 18 were analyzed. In addition to the 18-20 year old age group, the age groups 21-24 and 45-49 were also studied for comparative purposes. It was found that: among drivers 18-20, there appeared to be nominal increases in fatal accidents after the lowering of the drinking age; such changes appear less important in view of the major year-to-year changes in preceding years when there was no change in law and among drivers not affected by the law; and in Massachusetts there was a 33% increase in licensed drivers 18-20 years old between 1965 and 1971, compared to 13% for older drivers, so that increases in fatal crashes among youth could be expected on the basis of increases in the number of licensed drivers alone.

by Richard Zylman

Publ: Police Chief v63 n1 p56-9 (Jan 1976)

1976 ; 16refs

Availability: See publication

HS-018 053

## **RAINFALL AND VISIBILITY--THE VIEW FROM BEHIND THE WHEEL**

The effect of rainfall on driver visibility is discussed. Visibility tests were conducted under natural and artificial rainfall. Two observers drove a 1968 Plymouth sedan on a 7,000 foot test track on which four obstacles were placed at a constant speed in the rain to determine the visual ranges from inside an automobile during natural rainfalls. As soon as the driver was able to distinguish an obstacle he notified the test monitor. The distance at which the observation was made, the outside illuminance, and the brightness of the obstacle as well as its background were measured. The rainfall intensity was measured continuously by a rain gauge. It was found that: there is insufficient visibility for safe passing maneuvers (around one of the obstacles, the rear of an unlighted vehicle) at high vehicle speeds if the rainfall intensity is over one inch per hour; variation of the visibility of the different targets is very high; and the brightness measurements yielded threshold contrasts ranging from 0.01 to 0.03. The rear hull of a 1966 flat white Buick was photographed from inside a 1968 Buick sedan at 0, 30, and 60 mph with rainfall intensities of 2.7, 3.9, 4.4, and 5.4 inches per hour to indicate the influence of rainfall intensity (in this case, artificial rainfall), vehicle speed, and windshield wiper rate on driver visibility. The following additional parameters were stabilized: illumination (cloudy day with little change in illumination); windshield clarity; rainfall droplet size was kept uniform; visual acuity of observer (all factors of the camera remained constant); and color, size, and distance of the subject (same object was photographed from the same distance each time). Photographs with indicated visibility levels are provided. The need for speed reduction under wet weather conditions is apparent.

by Don L. Ivey; Eero K. Lehtipuu; Joe W. Button

Publ: Journal of Safety Research v7 n4 p156-69 (Dec 1975)

1975 ; 10refs

Availability: See publication

HS-018 054

## **THE PSYCHOMETRIC PREDICTION OF NEGLIGENT DRIVER RECIDIVISM**

A study was conducted to determine if recidivism status following a group driver improvement meeting could be predicted from biographical and psychometric data. A secondary objective of the study was to conduct a prediction study free of many of the methodological deficiencies in past research. Factors were evaluated in the present study from: basic biographical information; personality and attitudes; perceptual-motor skills; verbal ability; traffic safety knowledge; and criminality. Subjects of the study were repeat traffic violators who were required to appear at a group educational meeting. Two samples were selected for study: 850 drivers who took a battery of group psychological and diagnostic tests during the meeting; and 2,337 drivers who attended the meeting but who did not take the tests. The statistical techniques used were the multiple covariance analysis; the multiple step-wise regression; and the cluster analysis. Collisions and convictions on file at the

crimen measures. Significant cross-validity coefficients of .11 and .33 were reported for collisions and convictions, respectively. Driving record and criminal record variables were the most influential predictors of subsequent driving record with psychological variables playing a relatively minor role. It was also discovered that only one prediction equation was necessary to predict both convictions and collisions. Results indicate that the equation used to predict subsequent convictions was also able to predict subsequent collisions as well as or better than the collision equation itself.

by Richard M. Harano

Publ: Journal of Safety Research v7 n4 p170-9 (Dec 1975)

1975 ; 20refs

Availability: See publication

HS-018 055

## **WHEN A SAFETY IMPROVEMENT IS NOT AN IMPROVEMENT**

Both passive and active objections to a safety system must be taken into consideration and solved if the instituted system is to be effective and reliable. A four-step system should be utilized in order to achieve effective application of the safety solution. It includes: engineering the specific problem or objection out of the system to the extent that it cannot or is unlikely to occur; designing into the system, method or procedure, an automatic function that will take immediate corrective action if and when the problem occurs; designing an automatic alarm into the system; and requiring that certain procedures be followed to avoid the potential problem. A case in point is automobile safety belts. In spite of the increased measure of safety afforded by the belts, many passengers would not wear the belts because of some personal objection. An alarm system was instituted whereby a buzzer sounded if the vehicle was in operation without the belts being fastened. Further research is being instituted whereby a vehicle will not start unless the passengers are wearing safety equipment. In conclusion, what may appear to be a solution may be rendered ineffective in application if objections to the solution are not taken into consideration and effectively countered.

by Quinton W. Goode

Publ: Professional Safety v21 n1 p42-5 (Jan 1976)

1976

Availability: See publication

HS-018 056

## **NOISE SOURCE REGULATION IN STATE AND LOCAL NOISE ORDINANCES. FINAL REPORT**

A summary of noise source regulations encompassed in current state laws and local ordinances is presented. The data which was extracted deals specifically with laws and ordinances stipulating specific decibel levels. State ordinances are summarized under the following categories: motor and recreational vehicles, including motorcycles; campers; automobiles; light trucks; and towed vehicles; and land use and general noise regulations. For localities, the categories are: motor and recreational vehicles; intrusive noise sources; stationary noise sources; construction noise; and miscellaneous noise regulations. Five tables are presented which illustrate regulations at the state level, including: a summary of the

concerning motor vehicles for street and highway use; a summary of acoustic requirements for the operation and sale of recreational vehicles, including snowmobiles; state recreational and off-road vehicle noise regulations; and noise regulations for state land use, for aircraft, airports, and railroads. Tables 6 through 11 summarize existing regulations of local jurisdictions. Included are: a summary of local jurisdictions with motor vehicle noise regulations; local jurisdiction noise regulations for self-propelled motor vehicles; a summary of local jurisdictions with recreational vehicle noise regulations; a summary of local jurisdictions with intrusive noise regulations (for such items as horns, whistles, air conditioners, fans, electronic equipment and claxons); a summary of local jurisdictions with land use regulations; and a summary of local jurisdictions with construction noise regulations.

Environmental Protection Agency, Office of Noise Abatement and Control, Crystal Mall 02, 1921 Jefferson Davis Hwy., Arlington, Va. 20460

Rept. No. EPA 550/9-75-020 ; 1975 ; 32p

Update of Noise Source Regulation in State and Local Ordinances, March 1, 1973.

Availability: NTIS

HS-018 057

## **THE TYRE [TIRE] SCENE**

With the growing demands for economy and safety in the area of automobile tires, many basic principles for tire performance are being reevaluated. Tire testing can be divided into three categories: braking performance; wear; and steering, handling and roadholding. To give some idea how modern tires differ in their characteristics, AUTOCAR tested four different types of Dunlop tires: a D75 cross-ply; an SP Sport fabric radial, an SP70 low profile fabric radial; and an SP4 steel-braced radial. Tests involved driving around a steering pad at increasing speeds (10-30 mph) recording steering effort and steering wheel angle needed to hold a steady rate of turn; and driving through a chicane--a double lane-change maneuver--at increasing speeds until the driver hit a marked pylon. The results indicate that the 70-series radial gains in cornering stiffness, but loses out in the effort demanded by the steering wheel. Except for very low cornering forces, the fabric radial tire calls for the least effort. At low speeds, the crossply tire gives the lightest steering load, which makes for easier parking and maneuvering. The steel-braced radial showed itself superior in the chicane test. While the cross-ply tire remains a favorite for motorists to whom low first cost is much desired, the fabric-braced radial seems a better all-round compromise in terms of price, steering effort and tread wear. For those interested in ultimate performance, the 70-series and steel-braced radials are the choices.

by Jeffrey Daniels

Publ: Autocar v144 n4124 p6-9 (22 Nov 1975)

1975

Availability: See publication

## **ON VEHICLE MOBILITY MEASUREMENT AND RECORDING SYSTEM**

An on-going U.S. Army Tank Automotive Command (TACOM), Maintenance/Product Assurance Directorate program, directed at the establishment of field maintenance-oriented diagnostic equipment which will improve the reliability and reduce the cost associated with keeping vehicles operational, is described. The program used technology previously developed for a M151 vehicle. The current study involved instrumenting an M35A2 2.5 ton truck with on-board transducers for monitoring pressure; temperature; speed; clutch slip; odometer; battery voltage and time and date information. Signal processing and tape-recording equipment were also installed, and the vehicle ran 20,000 miles in idle and running modes. All measurement points were calibrated by traceable standards. Data was provided for hot and cold idle and motive vehicle operation, as well as for clutch slip, compression balance, and engine power measurements. The vehicle is presently undergoing road testing over highway, secondary and cross country terrain. The data collected will be computer analyzed to establish "good" and "bad" levels for diagnostic reference purposes.

by F. K. Chin; R. Watts

General American Transportation Corp., Res. Div., 7449 N. Natchez Ave., Niles, Ill. 60648; Army Tank Automotive Com., MVCT-Maintenance, Warren, Mich. 48090

Publ: (NBS-SP-436) Mechanical Failures Prevention Group, Proceedings of the 22nd Meeting, Gaithersburg, Md., 1975, p195-220

1975  
Conference held in Anaheim, Calif., 23-25 Apr 1975. Research sponsored by the Army Tank Automotive Command, Warren, Mich.

Availability: See publication

HS-018 059

## **DEVELOPMENT OF INSPECTION AND DIAGNOSTIC EQUIPMENT FOR MOTOR VEHICLE EQUIPMENT FOR MOTOR VEHICLE INSPECTION**

There is an important need for improving the present cursory and basically manual system of motor vehicle inspection. The first step in this process is to recommend to the states the most safety critical defects for an MVI (motor vehicle inspection) program; and the second step is to develop techniques, simple equipment and hand tools and procedures to improve the manual inspections. The systems which are listed as safety critical in order of priority are: braking systems, including brake components; tires; and steering and suspension systems, including shock absorbers. Future research activities should focus on appropriate and essential test techniques and equipment development and implementation, particularly since statewide motor vehicle inspection is presently, and will most likely be in the future, conducted in private garages, service stations and dealerships throughout the state.

by George L. Parker

National Hwy. Traffic Safety Administration, Vehicles-in-Use Group, Washington, D. C. 20590

Publ: (NBS-SP-436) Mechanical Failures Prevention Group, Proceedings of the 22nd Meeting, Gaithersburg, Md., 1975, p185-94

1975  
Conference held in Anaheim, Calif., 23-25 Apr 1975.

Availability: See publication

## **NONDESTRUCTIVE TIRE INSPECTION**

The National Highway Traffic Safety Administration initiated a research effort in the area of nondestructive testing (NDT) which could apply to inspection and test of motor vehicle tires. The prime objective of this program was to determine the feasibility and practicality of utilizing NDT techniques to inspect and predict dynamic tire performance. A technique which relies on exciting the tire to its resonant frequency at the tread center and utilizing symmetrically placed receiving transducers on the sidewalls to detect imbalances in the output signals was chosen. During laboratory evaluation, tires to be inspected are mounted on standard automotive wheels, inflated to normal operating pressure, and placed on a tire tester hub. The exciting transducer input roller is mechanically placed in contact with the tire at the center of the tread. Receiver transducers are positioned perpendicular to the tire sidewall surface at equal distances. The tire is rotated at about one revolution per minute. System evaluation is based on numerous tests for which data recordings are obtained. The tire was then destructively analyzed to confirm the system's detection capability. Excellent detection capability was obtained for tire defects which may lead to or result in tire failure, including: cuts; tread chunking; uneven wear; broken cords; and separations. In all cases, these defects will, in general, upset the symmetry of the tire, and therefore affect the resonant vibration properties of the tire. Photographs of the various inspection systems are included: the closed circuit television x-ray system; the infrared system; the holographic system; the reflection ultrasonic system; the transmission ultrasonic system; and the resonance systems. Resonant vibration patterns are illustrated and test apparatus are diagrammed.

by Manuel J. Lourenco; Lloyd H. Emery

National Hwy. Traffic Safety Administration, Crash Avoidance Res. Div., Washington, D.C. 20590

Publ: (NBS-SP-436) Mechanical Failures Prevention Group, Proceedings of the 22nd Meeting, Gaithersburg, Md., 1975, p43-77

1975 ; 7refs

Conference held in Anaheim, Calif., 23-25 Apr 1975.

Availability: See publication

HS-018 061

## **MEASUREMENT OF SPECTRA IN INTERNAL COMBUSTION ENGINE CYLINDERS**

The emission of light from chemical reactions is a general phenomenon. In internal combustion engines, when fuel is mixed with oxygen, compressed and ignited, the chemical reactions which take place are quite energetic, and produce a vigorous emission of light. Spectral measurements of light emitted during the combustion process could be hypothetically used to measure abnormal conditions occurring during internal combustion such as: oil burning; rust or metal shavings in the combustion chamber; hostile ambient conditions such as salt mist; and abnormal fuel components. Since temperatures in a combustion plasma can be as high as 4000 degrees F, small elements and metal fragments can be vaporized, producing atoms which will become electronically excited and emit light at their characteristic wavelengths (modified some by the environment). Spectral observations were made using a cooperative fuels research engine having a slit in one of the test ports which contained a borosilicate window and through which observation of the visible light emitted during the combustion

stroke could be made. The spectra obtained consisted of two very distinct types: sharp, and broad-structured. Two transient sharp lines were tentatively assigned as due to sodium and potassium on the basis of wavelength position. Although much more work is needed in confirming the interpretation of spectra, it appears that spectral observations can add effectively to the measurement area for diagnosing failures in both internal and external combustion engines. A discussion of the system, and panel discussion on planning and executing experimental verification are included.

by Jere M. Marrs

Tektronix, Inc., Beaverton, Ore. 97077

Publ: (NBS-SP-436) Mechanical Failures Prevention Group, Proceedings of the 22nd Meeting, Gaithersburg, Md., 1975, p78-94

1975; 4 refs

Conference held in Anaheim, Calif., 23-25 Apr 1975.

Availability: See publication

HS-018 062

### **BIOMECHANICS OF SERIOUS TRAUMA. PROCEEDINGS OF THE 2ND INTERNATIONAL CONFERENCE, BIRMINGHAM, SEPTEMBER 9, 10, 11, 1975**

Studies of serious trauma, head and neck injuries through accident analysis are presented in a series of papers. Emphasis is on head, spinal and neck injuries through a variety of situations: frontal collisions; collisions with pedestrians; correlations between accident circumstances and the type of injury; the effect of safety belts on types of injuries; and the influence of speed and impact on injuries. Studies were presented in English, as well as French and German. Experimental work using cadavers, living humans, rabbits, and baboons is also presented.

by J. P. Cotte, comp.; M. M. Presle, comp.

International Res. Com. on the Biokinetics of Impact, IRCOBI Secretariate, 109 avenue Salvador Allende, 69500 Bron, France

1975; 323p refs

Includes HS-018 063--HS-018 079.

Availability: Corporate author

HS-018 063

### **HEAD AND NECK INJURIES TO CAR OCCUPANTS WEARING SAFETY BELTS IN FRONTAL COLLISIONS**

An analysis was made of injuries to belt wearers in 182 frontal impact cases, involving 277 automobile occupants wearing safety belts. The survey results are summarized in tables which depict injuries to different regions of the body in terms of severity, from minor to severe; injuries to the head greater than minor severity; and details of accidents in which concussion occurred without accompanying head injuries such as cuts and bruises. The conclusions of the survey of all 182 frontal impacts suggest that when an automobile occupant wearing a 3-point lap-and-diagonal safety belt suffers concussion in an accident of this type, it is almost always the result of impact of the head with the inside of the car. There was also evidence that the neck injuries that occur in such impacts are infrequent and usually minor ones, and are unlikely to be accompanied by head injury. The results do not provide any support for a

head injury criterion for wearers of safety belts of the type considered, except in cases where the head strikes the inside of the vehicle.

by G. Grime

University Coll., Traffic Studies Group, London

Publ: HS-018 062, Biomechanics of Serious Trauma.

International Conference (2nd) Proceedings, Amsterdam, p30-9 1975?; 1ref

Conference held in Birmingham, 9-11 Sep 1975. Supported by the Transport and Rd. Res. Lab. Prepared in cooperation with Britax Ltd.

Availability: In HS-018 062

HS-018 064

### **CORRELATIONS BETWEEN ACCIDENT CIRCUMSTANCES AND THE TYPE AND GRADE OF INJURIES IN TRAFFIC ACCIDENTS**

A total of 10763 traffic casualties were analyzed for distribution and predicted severity of lesions according to age and accident situation. Head injuries dominated in children automobile riders compared with adults. Leg injuries dominated when unprotected road users (pedestrians, moped riders, cyclists and motorcyclists) were hit by automobiles. Fatality was 4 times greater in the age group above 65 years. The number of head lesions was clearly reduced in users of seat belts. It could not be demonstrated that there was an increased occurrence of neck lesions or serious lesions to the thorax or abdomen in 199 users of seat belts. In 340 helmeted moped riders and 189 helmeted motorcyclists an anticipated relative reduction in number of head injuries was demonstrated, but not an increased number of neck lesions.

by William Damholt; H. Victor Nielsen; Erik L. Nordentoft Odense Univ. Hosp., Denmark

Publ: HS-018 062, Biomechanics of Serious Trauma.

International Conference (2nd) Proceedings, Amsterdam, p40-9 1975?; 9refs

Conference held in Birmingham, 9-11 Sep 1975.

Availability: In HS-018 062

HS-018 065

### **BIOMECHANICAL ASPECTS IN THE CRITICAL CERVICAL TRAUMAS**

Over a period of 7 years (1968-1974), 100 post-mortem examinations on traumatized patients, 90 of them having a cervical lesion as the determinant cause of their death, and 10 of them having cervical lesions as a determining factor, were performed. In 56% of the cases, road accidents were the determining agent in injury. In studies of automobile, motorcycle, bicycle, front seat passenger, back seat passenger, driver and pedestrians, it was found that lesions of the cervical spine mostly appeared with those persons who were not ejected from the vehicles. It was also found that the frequency and seriousness of the cervical vertebral medullary lesions steadily increased with industrialization, increased traffic, and the speeding up of the rhythm of life. Among the causative agents, traffic accidents bear the first place by lethal and unlethal cervical lesions and the most frequently encountered mechanism in the production of these lesions is the "whiplash" injury. In spite of the fact that there is no consistent correlation between trauma-anatomical bone lesion and medullo-radicular anatomic lesion, the increased force of the agent combined with a particular direction of action of the agent (especially

rotation) produces most often cervical laceration-contusion lesions. The prognosis of these lesions is generally preserved and the therapeutical problems are not completely solved.

by G. Scripcaru; N. Ianovici; M. Anghel

Institute of Forensic Medicine, Jassy, Romania

Publ: HS-018 062, Biomechanics of Serious Trauma.

International Conference (2nd) Proceedings, Amsterdam, p62-71

1975?; 19refs

Conference held in Birmingham, 9-11 Sep 1975.

Availability: In HS-018 062

HS-018 066

### **INFLUENCE OF IMPACT SPEED AND VEHICLE PARAMETER ON INJURIES OF CHILDREN AND ADULTS IN PEDESTRIAN ACCIDENTS**

A two-year study was conducted, in which 550 accidents were investigated on the scene. Included in the study were 150 pedestrian accidents, 80 accidents involving children younger than 15 years, and 70 accidents involving adults over 15 years. The mean impact speed in nonfatal and fatal pedestrian accidents was calculated to be 34 kilometers per hour. Investigation parameters included: impact speed; car shape; car weight; pedestrian size and age; and size of car. Accident investigation showed the following trends: medium size cars are most often involved in accidents; up to 40 kilometers per hour, drivers underestimate the impact speed; pedestrians are impacted almost only on their sides; the throw off distance of children is 26% wider than adults; the throw off distance for pontoon shaped cars compared to V-shaped cars is 29% wider; in lighter accidents children are more endangered than adults; and in severe accidents, the elderly adult is more endangered. It was also found that: the most aggressive exterior parts of the car for children are the hood, the bumper and the windshield, and for adults the bumper, the hood and the windshield frame; the design of the front end influences drastically the rank of the most aggressive exterior car part; the aggressivity of exterior car parts consists in injury frequency and injury severity essentially as a product of both; heavy automobiles produce at all impact speeds more severe injuries than light automobiles; the size of the automobile does not influence the injury severity; and there is no difference in the injury severity caused by the second collision between pontoon and V-shaped automobiles. It was also found that the most endangered body parts in children are the head, abdomen and legs. For adults, it is the head, thorax, pelvis and lower legs. The secondary road surface impact produces at all impact speeds less severe injuries than the primary car impact. Up to 43 kilometers per hour impact speed, the pontoon shaped cars produce more severe injuries compared to V-shaped cars; over 43 kilometers per hour, less severe.

by H. Appel; G. Sturtz; L. Gotzen

Technische Univ., Inst. of Automotive Engineering, Berlin;

Medical Univ., Accident Surgery, Hannover

Publ: HS-018 062, Biomechanics of Serious Trauma.

International Conference (2nd) Proceedings, Amsterdam, p83-100

1975?; 21refs

Conference held in Birmingham, 9-11 Sep 1975.

Availability: In HS-018 062

HS-018 067

### **THE CAUSE AND NATURE OF HEAD INJURIES SUSTAINED BY PEDESTRIANS**

Cases from an on-going at-the-scene study of pedestrian accidents in the city of Birmingham are used to describe the injuries sustained by pedestrians struck by automobiles. About 280 accidents were analyzed in which the vehicle involved was an automobile or automobile derivative, for incidence of head and leg injuries - all severities; incidence of head and leg injuries - excluding minor injuries; incidence of non-minor head and leg injuries - fatalities; overall injury severity by age of pedestrian; comparison of severity of injuries for children and adults; overall injury severity by impact speed on children and adults; injuries sustained by children in frontal impacts; injuries sustained by children in front corner and side front impacts; injuries sustained by adults in frontal impacts; and injuries sustained by adults in front corner and side impacts. The results of the study suggest that: children sustain less severe injuries than adults at high impact speeds and this is mainly due to their sustaining less severe head injuries; for both children and adults, the head is the body area sustaining life-threatening or fatal injuries; life-threatening or fatal head injuries are more often caused by vehicle contact than by road contact; and the windshield frame is responsible for most of the life-threatening or fatal head injuries caused by vehicle contact.

by S. J. Ashton

University of Birmingham, Dept. of Transportation and Environmental Planning, United Kingdom

Publ: HS-018 062, Biomechanics of Serious Trauma.

International Conference (2nd) Proceedings, Amsterdam, p101-13

1975?; 13refs

Conference held in Birmingham, 9-11 Sep 1975. Research performed under contract to the Transport and Rd. Res. Lab.

Availability: In HS-018 062

HS-018 068

### **INTRACRANIAL OR NECK INJURY IN BELTED CAR OCCUPANTS**

An in-depth study was made of 117 seriously or fatally injured belted front seat occupants of automobiles, all of whom were involved in frontal impact accidents. Among the seriously or fatally injured belted occupants without evidence of head contact, clinically important injury to the cranial contents or to the deep structures of the neck was uncommon. Among the seriously or fatally injured belted occupants with evidence of head contact, the proportion of casualties with neck injury more severe than minor was less than among those without head contact, although the number with head injuries was greater. For these two groups of casualties, there was no significant difference in the mean of the velocity change for the involved vehicles for which calculations were made: 48 kilometers per hour (km/h) for casualties without head contact, and 49 km/h for those with head contact.

by E. Grattan; Nancy G. Clegg; J. G. Wall  
Department of the Environment, Transport and Rd. Res. Lab.,  
Crowthorne, Berks, England

Publ: HS-018 062, Biomechanics of Serious Trauma.

International Conference (2nd) Proceedings, Amsterdam, p114-20

1975?; 7refs

Conference held in Birmingham, 9-11 Sep 1975.

Availability: In HS-018 062



HS-018 069

## MEASURES OF SEVERITY OF INJURY

The development of an understanding of the mechanisms of injury in order to prevent or mitigate future injury is desired. The Abbreviated Injury Scale (A.I.S.) was an early attempt at establishing such a measure of injury, based upon comparative assessment of injuries on a 5 point scale of injury. The basic criterion was "threat to life", but this has been modified with measurements of treatment time and impairment. There is also some relation to energy of impact if only one body site is considered. The injuring effect of a given amount of energy also depends on the size of the area of impact. The A.I.S. is best suited to single injuries, so the Injury Severity Score (I.S.S.) was developed to give a more promising relation to mortality in a series of traffic accident cases. The Probit analysis as the index of severity in lethal burn cases (which established a 50% "lethal dose" of burning for given ages), was recalculated and found to exhibit a similar relation to mortality and age in automobile accident cases. By constructing equal mortality contours for combinations of I.S.S. and age, a grid of expected mortality for different I.S.S. at different ages could be obtained. Findings with disability are similar. Permanent disability was ranked on a 5 point scale from the most severe (severe brain damage) to minor disability (slight loss of limb function). Analysis confirms that the I.S.S. ratings proposed corresponded well to mortality for given ages. Improvements could be made, however, in increasing the weighting values more steeply; and in further subdividing severity of injury in order to provide a more clinically accurate measure of severity when pre-judging the mortality outcome.

by J. P. Bull  
Birmingham Accident Hosp., M.R.C. Res. Unit, Birmingham, England  
Publ: HS-018 062, Biomechanics of Serious Trauma.  
International Conference (2nd) Proceedings, Amsterdam, p121-5

1975?; 7refs  
Conference held in Birmingham, 9-11 Sep 1975.  
Availability: In HS-018 062

HS-018 070

## REACTIONS OF THE CERVICAL SPINE DURING FRONTAL IMPACTS OF BELT PROTECTED CADAVERS

Fifty-nine frontal barrier tests with human cadavers were carried out using point-standard safety belt with automatic retractor (34 cases); three-point-belt with force limiter and preloading device (three cases); two-point-belt with kneebar (four cases); and two-point-belt, automatic retractor with force limiter and preloading device (18 cases). The impact speed was 30 kilometers per hour (km/h) (two tests); 40 km/h (five tests); 50 km/h (47 tests); and 65 km/h (five tests). The observed injury degrees (patho-anatomical observed AIS scale) run up to zero at three cases, to one at four cases, to two at 13 cases, to three at 29 cases, and to four at ten cases. The severity degree was increasing according to the age of the subjects. At four tests, displacement plots, angle-time-histories, angle velocity-time-histories of the cranial-cervical and the cervical-thoracic axis have been investigated by optical evaluation of high-speed films. A greater displacement occurred at a greater seating height, however, not at a greater body weight. During the first 40 milliseconds (ms) (30 km/h impact velocity) respectively, 50 ms (40 km/h impact velocity) a purely translatory movement

of the cervical spine takes place. Maximum flexion angles have been attained at 30 km/h after 130 ms to 160 ms; at 40 km/h at 110 ms. The angle velocities were higher for more serious injured cervical spines than that for slightly injured ones. Velocities of 98, 54, 26 and 23 radians per second have been calculated for the angle of the cervico-thoracic transition.

by D. Kallieris; B. Meister; G. Schmidt  
University Heidelberg, Inst. for Forensic Medicine  
Publ: HS-018 062, Biomechanics of Serious Trauma.  
International Conference (2nd) Proceedings, Amsterdam, p126-42  
1975?; 19refs  
Conference held in Birmingham, 9-11 Sep 1975. Sponsored in part by Forschungsvereinigung Automobiltechnik e.V., Frankfurt, West Germany. Prepared in cooperation with F. Schulz and Volkswagenwerk AG.  
Availability: In HS-018 062

HS-018 071

## A STUDY OF HEAD IMPACTS IN LIVING MAN USING RADIOTELEMETRY

A study, undertaken to gather information on head mechanics during impact, was carried out on a football field. A telemetry system was designed to measure mechanical and physiological data of a player during a regulation football game. The system was capable of delivering six channels of data, while mounted in the helmet. Accelerations were measured with a linear accelerometer mounted on the suspension system of the helmet at each of three points on the head--at the midoccipital region and at both temporal areas. Only one player was instrumented during each of five seasons, and 1085 impacts were accepted for measurement. A complex response consisting of multiple peaks of acceleration of varying amplitudes resulted from each impact. Concussion followed one of these impacts. Telemetered data of head impacts encountered on the football field showed that the peaks of acceleration were quite similar in magnitude to those produced in the laboratory. Reactions of the instrumented player undergoing test impacts were studied to analyze the physiologic response, and to document the method employed to dissipate the force. It was found that the player's "state of readiness" prolonged the time of the impact and enabled his physiologic response to become operative. It was further found that stretching of the cervical spinal cord resulted in some effect on the activity of the reticular core of the brain stem; the direction of the blow and its point of contact on the left frontotemporal area of the head resulted in an unmeasured amount of rotational acceleration of the brain; and a similar high intensity impact was encountered at an area on the head directly opposite the site of impingement of the concussion-producing blow.

by S. E. Reid; H. M. Epstein; T. J. O'Dea; M. W. Lewis; S. E. Reid, Jr.  
Evanston Hosp. and Northwestern Univ. Medical School, Chicago, Ill.  
Publ: HS-018 062, Biomechanics of Serious Trauma.  
International Conference (2nd) Proceedings, Amsterdam, p143-52  
1975?; 6refs  
Conference held in Birmingham, 9-11 Sep 1975.  
Availability: In HS-018 062

HS-018 072

# **HUMAN HEAD IMPACT RESPONSE EXPERIMENTAL DATA AND ANALYTICAL SIMULATIONS**

Human cadaver head acceleration-time responses to direct front, occipital, and temporal head impacts were studied. Factors influencing the measured responses included: striker weight; initial cadaver head positioning; sites and inclinations of head accelerometers; cadaver stiffness; skull vibrations; and location of impact. Skull surface acceleration-time profiles illustrated that vibrational effects superimposed on the inertial motion greatly influenced the local magnitudes and time characteristics. Magnitudes of vibrational accelerations relative to the inertial value suggest that closed head, for rigid impacts, can be induced by oscillatory accelerations at the contre-coup site. For padded impacts, the inertial response is dominant and higher impact levels are required to produce contre-coup injury. Model simulation and high speed photographic data both suggest significant rotational effects. The region at the base of the ear acts as an instantaneous center for the contact phase, and undergoes linear motion for frontal and occipital impacts. Fractures in all cases were depressed stellate fractures. Fracture force values are compatible with previously published data.

by Sunder H. Advani; William R. Powell; Jeffrey Huston; Steven J. Ojala  
West Virginia Univ., Dept. of Mechanical Engineering and Mechanics, Morgantown, W. Va. 26506  
Publ: HS-018 062, Biomechanics of Serious Trauma, International Conference (2nd) Proceedings, Amsterdam, p153-63  
1975?; 9refs  
Conference held in Birmingham, 9-11 Sep 1975.  
Availability: In HS-018 062

HS-018 073

# **EXPERIMENTAL BRAIN DAMAGE FROM FLUID PRESSURE DUE TO IMPACT ACCELERATION. STUDY OF EFFECTS OF "CONTRE-COUP TYPE" PRESSURE CHANGES INTRACRANIALY IN RABBITS**

A rigid fluid filled cylinder was connected with the skull cavity of 6 rabbits. The cylinder was impacted and the intracranial contents acted as a contre-coup end. Production of a pressure pattern similar to that encountered in the human head at a blunt impact was possible. Studies showed that acceleration-velocity-dislocation of the rabbit head could be varied and predicted; skull deformation was minimized; reliable intracranial pressure measurements could be performed; varied intracranial pressure changes of "contre-coup type" including subatmospheric pressure transients near -1 atmosphere could be obtained; and to some extent intracranial tissue displacement could be estimated.

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Publ: HS-018 062, Biomechanics of Serious Trauma, International Conference (2nd) Proceedings, Amsterdam, p164-76  
1975?; 43refs  
Conference held in Birmingham, 9-11 Sep 1975.  
Availability: In HS-018 062

HS-018 074

# **THE GADD SEVERITY INDEX AND MEASUREMENTS OF ACCELERATION WHEN HEADING AN ASSOCIATION FOOTBALL**

There are many similarities between blows suffered to the head due to heading a football and those encountered in automobile and other motor accidents. The best known criterion for gauging head damage is the Gadd Severity Index (GSI). It denotes a linear acceleration in g's undergone by the head of an adult when subjected to a blow in the middle of the forehead; if this is raised to the power of 2.5 and integrated with respect to time over the period of the blow or pulse of total duration, then severe concussion in a normal healthy adult is likely if the Index exceeds 1,000, provided the duration is between 2.5 and 60 milliseconds. Experiments to measure heading impact using the GSI were conducted at various ranges of speed, with the lower range of impact speed having human targets; and the higher speeds using a pneumatic actuator with a punch ball. Maximum acceleration was plotted against corresponding impact speed logarithmically, and results were separated into two branches: velocity greater than 70 feet per second; and velocity less than 70 feet per second. By impacting the human target and weighted punch ball, an assessment of the severity of impact was obtained. A realistic maximum speed of 120 feet per second was assessed on the GSI as 230. This indicates that the single event of direct heading of a football, with no rotation of the head occurring, is not likely to be damaging. Considering the rapidity with which the index increases with acceleration, an acceleration component resulting from rotation could conceivably cause the severity to exceed the limit of tolerance. When assessing the severity of impact experimentally, attention must be paid to those factors which influence the less obvious effects associated with the particular impact mechanism being considered.

by W. Johnson; J. Skorecki; S. R. Reid  
University of Manchester Inst. of Science and Tech., Dept. of Mechanical Engineering, England  
Publ: HS-018 062, Biomechanics of Serious Trauma, International Conference (2nd) Proceedings, Amsterdam, p187-96  
1975?; 6refs  
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HS-018 075

# **CHANGES IN THE DYNAMIC BEHAVIOUR OF THE BABOON'S HEAD AND NECK SYSTEM SUBJECTED TO A FRONTAL DECELERATION (-GX), RELATED TO THE ACTION OF CERVICAL MUSCLES**

A study of the dynamic behavior of the head-neck system and muscular influence and the use of automobile safety belts was conducted. Seven adult baboons were chosen due to the fact that a baboon's shape is close to human. The animals were launched on a sled at speeds up to 80 kilometers per hour, followed by rapid deceleration. Parameters involved were: speed of launching; speed of deceleration; duration of deceleration; muscular tonicity; and geometric parameter measurement. A total of 95 tests were conducted with different conditions of launching speed and muscular tonicity. The experiments showed the main characteristics of the dynamic response of a baboon's head-neck system submitted to a frontal deceleration. Translational and rotational movements of the head, with respect to the thorax were found. The part of the muscular ac-

tion in the dynamic behavior of the head-neck system has been pointed out as an action reducing the maximum head angular acceleration by about 40%. Representation with two axes of rotation enables the description of the movements of the head-neck system with six angular variables: angular displacement, velocity and acceleration for both axes. Modelization owing to this two axes system should enable the expression of muscular influence in terms of stiffness and viscosity variation, which may be incorporated into the improvement of anthropomorphic dummies.

by J. P. Verriest; F. Martin; P. Viviani  
ONSER, Laboratoire des Chocs, Bron, France; Laboratoire de Physiologie du Travail du CNAM, Paris, France  
Publ: HS-018 062, Biomechanics of Serious Trauma.  
International Conference (2nd) Proceedings, Amsterdam, p207-19  
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HS-018 076

### **INJURY TO EYE AND FACIAL SKIN (RABBIT) ON IMPACT WITH INFLATING AIR BAG**

Because there is some apprehension about the possibility of injury occurring if the surface of an inflating air bag were to strike the face or eye of passengers in an automobile collision, an experiment was devised to test the results of such an impact. In evaluating injury, three mechanical factors were considered: inflation velocity; bag maximum internal pressure; and impulse at bag impact. A total of 37 rabbits, with eyelids sutured open, were placed in a wooden box. In order to find the impulse on the rabbit's eye, an impulse measurement device (an eye model constructed of polyvinyl chloride) was used to serve as a cornea at the instant of impact. Permissible safety thresholds were derived on the basis of the experimental results. The reported time required for a human eye to blink is 28-217 milliseconds. Since the inflation time of commercial air bags is 25-35 milliseconds, it is entirely conceivable that eye injury can occur. Even though it was demonstrated that the air bag does constitute a source of danger to eye and facial skin, it is not recommended that air bag development and application be arrested.

by Atsumi Kikuchi; Mitsuo Horii; Akihiro Kawai; Sachiko Kawai; Yoshio Komaki; Masanori Matsuno  
Japan Automobile Res. Inst., Inc. (JARII) Human Factors Engineering Div., Yatabe-cho, Ibaraki-ken, Japan  
Publ: HS-018 062, Biomechanics of Serious Trauma.  
International Conference (2nd) Proceedings, Amsterdam, p240, 289-96  
1975?  
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HS-018 077

### **THE IMPACT PROPERTIES OF BONE**

Studies were conducted to determine the mechanical properties of bone in areas where the human bone is subject to high amounts of stress as in an automobile collision impact. In this study, human femoral cortical bone was tested in tension at a rate of 2 per second, producing a fracture in 20 to 30 milliseconds. Tensile testing was used because it has been shown that the majority of fractures "in vivo" in the femur occur

along the planes of maximum tensile strength. Specimens were prepared from the mid 100 centimeters (cm) of the femoral diaphysis at post mortem, and sealed in plastic bags. Testing was carried out on a Mayes Universal Hydraulic testing machine with a flat frequency response of 4 HZ plus or minus 1 millimeter (mm). An extensometer was built to measure bone strain directly. The extensometer output was fed through a carrier amplifier, a noise reduction system and displayed on an oscilloscope. The load cell output was also put through the noise reduction system before being displayed. Ram speed used was 1500 mm per minute. Films taken of the tensile tests, show that the crack propagation always took less than 1 frame, meaning that the minimum crack propagation speed was 10 meters per second. Parameters measured in the mechanical tests were ultimate tensile strength, modulus of elasticity, percentage elongation of the specimen and energy absorbed to fracture. Correlation between percentage elongation and energy absorption is significant at the 5% level. Correlation between ultimate tensile strength and energy absorption is significant at the 5% level. Ultimate strength increases the further along the fracture occurs, establishing, to a certain extent, the theory that energy absorption is a criteria for bone strength.

by R. P. Dickenson; J. W. Wall; W. C. Hutton  
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International Conference (2nd) Proceedings, Amsterdam, p249-56  
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HS-018 078

### **DETERMINATION OF INJURY THRESHOLD LEVELS BY RECONSTRUCTION OF REAL ROAD ACCIDENTS**

The best possibility of investigating the real load of automobile occupants in the injury threshold range consists in the reconstruction of suitable road accidents. After assessing the damage to parts in the interior of the vehicle, and the injuries to the occupants, the damage is simulated in the laboratory. Subsequently, the loads which have caused the injuries are measured in dynamic and static experiments. After definition of the threshold levels, injuries to body parts and loads are then correlated. First results demonstrate that this method yields statistically significant tolerance levels, provided that a sufficient number of cases is investigated. In addition, it is possible to check data determined by other methods. Interior structural damage corresponding to that resulting from real accidents was produced in 15 impact experiments, and the loads for deceleration and impact load acting on the equivalent shoulder mass were measured. It is possible to investigate any conceivable impact situation. The most important investigations that should be conducted for further refining the reconstruction method are an exact description of the constitution of the automobile occupants and use of electronic data processing. This not only reduces the amount of work involved, but also permits a more rapid and less expensive variation of impact parameters compared with the impact experiment.

by G. Ruter; H. Hontschik  
Battelle-Institut e.V., Frankfurt am Main, Germany  
Publ: HS-018 062, Biomechanics of Serious Trauma.  
International Conference (2nd) Proceedings, Amsterdam, p279-87

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HS-018 079

## RESEARCH ON BIOLOGICAL EFFECTS OF IMPACT ACCELERATION WAVE PATTERNS

To study effects on bodies of impact acceleration wave patterns were conducted. Embryos of fertilized hen's eggs were used as huge single cells, rats as vertebrates, and monkeys as an anthropoid close to man. The test was designed to find: the relationship between weight of test subject and tolerance to impact; the relationship of mortality to acceleration and duration time change, while impact speed is constant; and the difference (if any) in the degree of resultant injury between different acceleration wave patterns when under the same impact conditions. Effects were studied of both square and sawtooth impact wave patterns. It was found that for acceleration patterns under the same impact conditions (speed and absorption distance remaining constant), the square pattern is safer than the terminal peak sawtooth and symmetrical triangular wave patterns. As for injury to bodies inflicted at the same impact speed, acceleration acts as a greater factor than duration of time. And finally, for injury inflicted on bodies under the same impact conditions, the degree of injury increases as the body weight of the subject increases.

by Masahiro Ojimi; Akihiro Kawai; Sachiko Kawai; Atsumi Kikuchi; Koshior Ono; Yoshio Komaki; Masanori Matsuno; Nobuo Moriyasu; Takashi Tsubokawa  
Japan Automobile Res. Inst., Inc. (JARI), Human Factors Engineering Div., Yatabe-cho, Ibaraki, Japan; Nihon Univ., Neurosurgery Dept.  
Publ: HS-018 062, Biomechanics of Serious Trauma.  
International Conference (2nd) Proceedings, Amsterdam, p288, 241-48  
1975?; 8refs  
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Availability: In HS-018 062

HS-018 080

## THE CARTER SYSTEM--A NEW APPROACH FOR A STEAM POWERED AUTOMOBILE

A steam powered Volkswagen has been tested by the Environmental Protection Agency and meets the 1977 emission levels without the use of add-on control devices. The steam system is unusual in its use of high pressure (up to 2500 pounds per square inch), high temperature steam (1100 degrees F) in conjunction with a high speed reciprocating expander (up to 6000 rpm), constant expansion ratio, variable pressure boiler, and a conventional automotive transmission to achieve an extremely compact design of high thermal efficiency. Test results and areas of improvement on the first prototype are discussed along with the steam engine characteristics and performance projections of the second prototype under construction. The first steam prototype was run on a test stand for nine months

accumulated over 6000 road miles. The steam system is described and illustrated by flow diagram and photographs and the performance of the second generation steam car is discussed. The second car should: have emissions of less than or equal to 0.08 grams per mile hydrocarbons, 0.7 grams per mile carbon monoxide, and 0.16 grams per mile nitric oxides; develop 15 more horsepower; and have a start-up time of approximately 15 seconds.

by Jay W. Carter, Jr.  
Jay Carter Enterprises, Inc.  
Rept. No. SAE-750071; 1975; 10p 1ref  
Presented at the Automotive Engineering Congress and Exposition, Detroit, Mich., 24-28 Feb 1975.  
Availability: SAE

HS-018 081

## SHOULD WE HAVE A NEW ENGINE? AN AUTOMOBILE POWER SYSTEMS EVALUATION. VOL. 1. SUMMARY

California Inst. of Tech., Jet Propulsion Lab.  
Rept. No. JPL-SP-43-17-Vol-1; SAE-SP-399; 1975; 111p 14refs  
Research supported by a grant from the Ford Motor Co. For abstract see HS-018 082.  
Availability: SAE as SP-399, \$3.50; SP-400-S, \$16.50, 2 vol. set

HS-018 082

## SHOULD WE HAVE A NEW ENGINE? AN AUTOMOBILE POWER SYSTEMS EVALUATION. VOL. 2. TECHNICAL REPORTS

Alternative automotive powerplants were examined for possible introduction during the 1980-1990 time period. Technical analyses were made of the Stratified-Charge Otto, diesel, Rankine (steam), Brayton (gas turbine), Stirling, electric, and hybrid powerplants as alternatives to the conventional Otto-cycle engine with its likely improvements. These alternatives were evaluated from a societal point of view in terms of energy consumption, urban air quality, cost to the consumer, materials availability, safety, and industry impact. Results show that the goals for emission reduction and energy conservation for the automobile over the next 5-10 years can be met by improvements to the Otto-cycle engine and to the vehicle. This provides time for the necessary development work on the Brayton and Stirling engines, which offer the promise of eliminating the automobile as a significant source of urban air pollution, dramatically reducing fuel consumption, and being saleable at a price differential which can be recovered in fuel savings by the first owner. The Brayton and Stirling engines require intensive component, system, and manufacturing process development at a funding level considerably higher than at present.

California Inst. of Tech., Jet Propulsion Lab.  
Rept. No. JPL-SP-43-17-Vol-2; SAE-SP-400; 1975; 557p refs  
Includes HS-018 083-018 101. Supported by a grant from the Ford Motor Co.  
Availability: SAE as SP-400, \$14.50; SAE, SP-400-S, \$16.50, 2 vol. set

HS-018 083

## **FUNDAMENTAL CONSIDERATIONS OF HEAT ENGINES FOR AUTOMOTIVE PROPULSION**

The characteristics of heat engines pertinent to their use in automobiles are identified. The technological states denoted as Present, Mature, and Advanced are discussed, with a detailed analysis of the performance which results from their application to the Otto, diesel, Rankine, Brayton, and Stirling engines. Some consideration of the basic thermodynamic processes of work production or absorption and heat addition or extraction common to all engines is given and the influence of these processes on the emissions and fuel consumption characteristics of the different types of engines is assessed.

by N. R. Moore; G. J. Nunz  
California Inst. of Tech., Jet Propulsion Lab.  
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1975 ; 20p 26refs  
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HS-018 084

## **THE UC OTTO AUTOMOTIVE POWER SYSTEM (BASELINE)**

Likely developments of the uniform-charge Otto powerplant are discussed. Consideration is given to the following factors: characteristics of the Otto-cycle engine (thermodynamics, engine performance, fuel requirements, pollutant formation); major subassemblies and components (descriptions, configurational evolution, producibility and cost); vehicle integration (engine packaging in vehicle, and transmission requirements); performance in vehicle (fuel economy, emissions, drivability aspects, and safety); ownership considerations (maintenance and cost of ownership); and research and development required (mature configuration and advanced configuration). Descriptions of major subassemblies and components include: induction system components; variable-Venturi carburetor; ultrasonic carburetor; sonic carburetor; pre vaporization devices; fuel injection systems; catalytic converters and accessories; oxidizing converters; reduction converters; and three-way converters (closed-loop induction control).

by G. J. Nunz; N. R. Moore  
California Inst. of Tech., Jet Propulsion Lab.  
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1975 ; 27p 26refs  
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HS-018 085

## **THE INTERMITTENT-COMBUSTION ALTERNATE AUTOMOTIVE POWER SYSTEMS: THE LEAN-BURNING OTTO ENGINE; THE STRATIFIED-CHARGE OTTO ENGINE; THE DIESEL ENGINE**

The performance costs and production capabilities of the lean-burning uniform-charge Otto engine, the stratified-charge Otto engine, and the diesel are discussed: characteristics (thermodynamics and pollutant formation, engine performance, summary and selection of engine types evaluated, and performance of mature stratified-charge Otto and diesel engines); major subassemblies and components (descriptions, configurational evolution, materials and producibility, and unit

costs); vehicle integration (engine packaging in vehicle, transmission requirements, and other vehicle design impacts); performance in vehicle (fuel economy, chemical emissions, noise emissions, drivability aspects, and safety); ownership considerations (maintenance and incremental cost of ownership); and research and development required (mature configurations and advanced configurations). Schematics of various fuel injection apparatus are provided.

by N. R. Moore; G. J. Nunz; G. J. Klose; W. A. Edmiston; T. A. Barber  
California Inst. of Tech., Jet Propulsion Lab.  
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1975 ; 61p 97refs  
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HS-018 086

## **THE BRAYTON AUTOMOTIVE POWER SYSTEM (GAS TURBINE ENGINE)**

The Brayton automotive power system, as applied in Brayton-cycle gas turbine engines, is examined. The following aspects of these engines are discussed: the operational steps of the basic engine cycle; the characteristics of the system (thermodynamics, performance, fuel requirements, and pollutant formation); major subassemblies/components (component descriptions, configurational evolution, materials and producibility, and unit costs); vehicle integration (engine packaging in vehicle, transmission requirements, other vehicle design impacts); performance in vehicle (fuel economy, chemical emissions, noise emissions, drivability aspects, and safety); ownership considerations (maintenance and incremental cost of ownership); and research and development required (mature configuration, advanced configuration, and production availability). Photographs of experimental gas turbine engine components and an exploded drawing of a Chrysler gas turbine engine are provided.

by G. J. Nunz; N. R. Moore; G. J. Klose; W. A. Edmiston; T. A. Barber  
California Inst. of Tech., Jet Propulsion Lab.  
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1975 ; 44p 64refs  
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HS-018 087

## **THE STIRLING AUTOMOTIVE POWER SYSTEM**

The Stirling engine, a machine in which the conversion of heat to work occurs through the alternate compression and expansion of a confined working fluid, which is at a lower temperature during compression than during expansion, is examined. The following aspects of the Stirling automotive power system are discussed: characteristics (thermodynamics, performance, fuel requirements, and pollutants); major subassemblies/components (descriptions, configurational evolution, materials and producibility, and unit costs); vehicle integration (engine packaging in vehicle, transmission requirements, and other impacts); performance in vehicle (fuel economy, chemical emissions, noise emissions, drivability aspects, and safety); ownership considerations (maintenance, and incremental cost of ownership); and research and development required (mature configuration and advanced configuration). Photographs and drawings illustrate the engine.

by G. J. Nunz; N. R. Moore; G. J. Klose; W. A. Edmiston; T. A. Barber  
 California Inst. of Tech., Jet Propulsion Lab.  
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 1975 ; 46p 52refs  
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HS-018 088

## THE RANKINE AUTOMOTIVE POWER SYSTEM

The Rankine cycle heat engine, a machine which utilizes a change in phase of the working fluid between liquid and vapor in the conversion of heat into mechanical work, is examined. The following aspects of this engine's power system are discussed: the selection of the working fluid and the expander; the characteristics (thermodynamics, engine performance, fuel requirements, and pollutant formation); major subassemblies and components (description of major components, configurational evolution, materials and producibility, and unit costs); vehicle integration (engine packaging in vehicle, transmission requirements, and other vehicle design impacts); performance in vehicle (fuel economy, chemical and noise emissions, drivability aspects, and safety); ownership considerations (maintenance, and incremental cost of ownership); and research and development required (mature configuration, advanced configuration, and availability for production). Photographs and schematics of the Rankine engine are provided.

by G. J. Nunz; N. R. Moore; S. P. DeGrey; G. J. Klose; W. A. Edmiston; T. A. Barber  
 California Inst. of Tech., Jet Propulsion Lab.  
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 1975 ; 35p 36refs  
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HS-018 089

## ELECTRIC VEHICLES

Electric or purely flywheel-powered vehicles are examined in terms of the following factors: system performance characteristics (energy economy, range performance, road performance, emissions performance); components (traction motor-controller, battery systems, and materials requirements); vehicle integration; ownership considerations (maintenance and incremental cost of ownership); and research and development recommendations (battery research and development and drive train research and development). It is concluded that a breakthrough in battery (or flywheel) technology is needed before electric vehicles can be expected to capture a significant fraction of the automotive market. Nearly total recycling of battery materials will be essential.

by H. C. Vivian; C. England  
 California Inst. of Tech., Jet Propulsion Lab.  
 Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a New Engine? Vol. 2, Pasadena, 1975 p8-1--8-26  
 1975 ; 26p 34refs  
 Availability: In HS-018 082

HS-018 090

## HYBRID VEHICLES

The development of hybrid vehicles is discussed. Hybrid vehicles can be classified according to their mechanical configuration (series or parallel), number of energy storage elements, types of energy storage components, and modes of operation. The following elements of hybrid vehicle development are examined: general description of the hybrid idea (background, hybrid system concepts, current state-of-the-art); performance projections (fuel economy, road performance, and emission performance); major system components (heat engines, batteries as energy storage systems, flywheels as energy storage systems, traction motors and generators, and power control systems); vehicle design and integration (weight, weight distribution and handling, packaging flexibility, volume constraints, and powerplant safety); and ownership considerations (maintenance requirements and incremental cost of ownership). It is concluded that: the initial cost of all types of hybrids will remain higher than that of conventional vehicles of equal performance and accommodations due to their added weight and complexity; and the life-cycle cost will also remain substantially greater until such time as fuel cost savings which result from improved fuel economy exceed the amortized increase in the initial cost plus the additional maintenance costs.

by H. C. Vivian  
 California Inst. of Tech., Jet Propulsion Lab.  
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 1975 ; 26p 18refs  
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HS-018 091

## VEHICLE SYSTEMS

Modifications in vehicle and component designs which can sharply reduce the fuel consumption of equivalent automobiles are described. The concept of an Otto-Engine Equivalent (OEE) car is established to evaluate alternate-engine vehicles. A computer program has been developed which can simulate operation of an automobile over any specified sequence of driving maneuvers. Six discrete car classes (mini, small, subcompact, compact, full-size, and large) were established to represent the range of cars available, because the effects of changes vary with car size and weight. The engine horsepower and major dimensions for the classes are shown. Weight propagation and equivalent performance for the OEE vehicle are discussed. Trends in United States car size and weight and size and weight comparisons of different cars in different classes are tabulated. Possibilities for future improvements in fuel economy are discussed: vehicle size, weight, and passenger space (car size and seating comfort, car size and weight, potential for weight reduction, reduction of exterior vehicle size, total weight reduction, and fleet weight reduction); and vehicle modifications and fuel economy (vehicle weight, transmissions, effect of engine size on reduced performance, aerodynamic drag, tires, improved accessories and accessory drives, and fuel economy measurements). Start-up and warm-up fuel consumption penalties are also considered.

by G. J. Klose  
 California Inst. of Tech., Jet Propulsion Lab.  
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 1975 ; 30p 44refs  
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HS-018 092

**MANUFACTURABILITY AND COSTS [OF ENGINES]**

Estimates of the selling price of various engines which are built up from unit variable costs, production facility and tooling costs and industry overheads are presented. The cost structure of engines can be broken down into unit variable costs, unit manufacturing costs, and consumer costs. The following costs are examined and tabulated for a variety of engines: variable costs, resource costs, return on investment, and unit costs. It is found that: the 3-way catalyst uniform charge (UC) Otto engine controlled to 0.41/3.4/0.4 emissions levels is over 60% more costly to manufacture than the pre-emissions Otto engine; the alternate powerplants costs lie within 35% of the all-up emissions-controlled UC Otto engine for equivalent performance vehicles; the capital/output ratios for the production of the Rankine, Stirling and Brayton engines are from 50 to 150% higher than the Otto engine; equivalent performance vehicles scaling allows an installed power reduction and hence an equivalent reduction in engine cost; direct production machinery costs for the Stirling, Rankine and Brayton engines are two to three times higher than for the Otto engine due to the stainless steel and superalloy content of these engines; and a vehicle with a Stirling or Brayton engine will cost about 10% more than a vehicle of equivalent performance with an Otto engine.

by T. A. Barber

California Inst. of Tech., Jet Propulsion Lab.

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New Engine? Vol. 2, Pasadena, 1975 p11-1--11-15

1975 ; 15p 9refs

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HS-018 093

**ALTERNATE HEAT ENGINE RESEARCH AND DEVELOPMENT**

Critical research and development (R&D) tasks which need to be completed if viable alternative heat engines to replace present-day internal combustion engines are to become a practical reality in the 1980-1990 time period are identified. It is found that: mass production of the mature Stirling engine, and of the Brayton engines can begin before the end of the 1980-90 decade, following direct R&D costs of about \$130 million each for the mature Stirling and the advanced turbine, and \$95 million for the mature turbine, if the R&D is carried out at the maximum effective expenditure rate; R&D for the advanced turbine engine should be emphasized since its functional and cost benefits heavily outweigh those of the mature engine; and in order to make superior alternate engines such as the Stirling and Brayton a production reality by 1990, automobile manufacturers may need to increase R&D expenditures for the development of prototypes to around \$15 million per year.

by R. W. Reibling

California Inst. of Tech., Jet Propulsion Lab.

Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a

New Engine? Vol. 2, Pasadena, 1975 p12-1--12-23

1975 ; 23p 6refs

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HS-018 094

**SCENARIO GENERATION [FOR VEHICLE FUEL CONSUMPTION AND EMISSIONS]**

The methodology used for the scenario calculations for future vehicle fuel consumption and emissions is discussed. A computer program was designed to calculate the amount of fuel consumed and pollutant emissions generated assuming different futures. The program requires that the following data be supplied for each year of interest: estimated passenger car vehicle miles traveled (VMT); estimated total passenger car registrations; and new car production mix for the scenario of interest. Using 15 years of historical data to obtain the present fuel economy and emissions characteristics of the vehicle fleet, the program has the following steps: beginning with 1975 it calculates the mean fuel consumption and emissions characteristics of the production mix; it estimates the distribution of VMT's by vehicle age for each year; it calculates the mean fuel consumption and emissions characteristics of the entire fleet of cars in 1975; and it determines the national energy consumption for automobiles and the emissions contribution of the automobiles for specific air basins. A simplified flow chart of the scenario generation program is given.

by S. D. Foulkes; K. L. Heitner

California Inst. of Tech., Jet Propulsion Lab.

Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a

New Engine? Vol. 2, Pasadena, 1975 p13-1--13-4

1975 ; 4p 6refs

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HS-018 095

**AUTOMOBILE USE**

External factors likely to affect automotive use are explored and the wide range of "futures" possible over the next 10-15 years is illustrated. Macropatterns of automobile use are discussed: factors underlying future vehicle use (driving age population, saturation of vehicle ownership, economic factors, increased use of alternate transportation systems, land use and related factors); alternate projections of vehicle use (annual use per vehicle, alternate projections of vehicle miles traveled, projection of the vehicle fleet size, vehicle fleet turnover, imported vehicles, future domestic production, light trucks); vehicle use data for specific urban basins (Los Angeles, New York City, and St. Louis); and research needs in macropatterns of vehicle use. Also examined are the micropatterns of automobile use: driving cycles (environmental factors; driving modes affecting energy use and emissions; trip length patterns and transient effects; changes in driver behavior; and daily range requirements for energy storage vehicles.

by K. L. Heitner; S. D. Foulkes

California Inst. of Tech., Jet Propulsion Lab.

Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a

New Engine? Vol. 2, Pasadena, 1975 p14-1--14-25

1975 ; 25p 59refs

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HS-018 096

**INDUSTRY PRACTICES [ALTERNATIVE ENGINE PRODUCTION AND PRODUCTION CONVERSION]**

These factors which are relevant to the time of introduction of

tain whether there are any significant barriers, technological or institutional, to their production and utilization. The time sequence of the auto industry's development of an alternate engine (technology, research and development, and product introduction) is discussed. The development of a Ford truck turbine (begun in 1968) is examined as an actual case of alternative development. It is concluded that: there appear to be no barriers to conversion to alternate engines; and there, appears significant reason for the automobile industry to develop the Brayton engine in its two versions and the Stirling engine for earliest possible sale. Automotive sales and capital expenditures (1964-1973) and metal cutting industry or tooling capacities (1960-1974) and expenditures are tabulated.

by T. A. Barber  
California Inst. of Tech., Jet Propulsion Lab.  
Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a New Engine? Vol. 2, Pasadena, 1975 p15-1-15-12  
1975 ; 12p 4refs  
Availability: In HS-018 082

HS-018 097

## VEHICLE AND HIGHWAY SAFETY

Vehicle and highway safety is discussed in terms of the following: engine safety aspects (intermittent-combustion engines, continuous-combustion engines, electric powerplants, and hybrid powerplants); vehicle safety aspects; and fleet safety aspects (mass introduction of alternate engines, shift of vehicle weight and fleet weight distribution, and use of safety restraints). It is concluded that: none of the alternate engine systems inherently constitute a major safety problem; vehicle safety does not have to imply weight increases; a shift to lower weight cars by an average of 500 pounds with no changes in vehicle design or restraint usage will increase the present highway accident injury rate by 15%; restraint systems such as lap and shoulder belts can reduce the chance of severe accident injury by over 50%; and the single largest contributor to highway casualties is alcohol.

by T. K. C. Peng; G. J. Nunz; G. J. Klose  
California Inst. of Tech., Jet Propulsion Lab.  
Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a New Engine? Vol. 2, Pasadena, 1975 p16-1-16-9  
1975 ; 9p 16refs  
Availability: In HS-018 082

HS-018 098

## ENERGY AND FUELS

Alternative energy sources are evaluated and costs and efficiencies for production of synthetic liquid fuels from coal are compared. Projections are made of: total domestic energy supply and demand situations (current energy balance and basis for projections, projection of likely domestic supply, and projection of total non-automotive energy demand); and the capability for satisfying petroleum demand (range of non-automotive demand for petroleum, scenarios for automobile fuel consumption, and comparison of projected domestic petroleum supply and demand). The demand for specific petroleum products is discussed in terms of: fuel characteristics for different engine types; factors affecting supply of specific products; and the use of methanol and methanol blends. The availability of electrical energy for vehicles is given consideration. It is concluded that: the viable fuels for automobiles through the 1990's will be liquid hydrocarbons, derived

primarily from petroleum and supplemented with synthetic liquids, either methanol or hydrocarbons, that can be produced from coal; refining costs and process energy consumption could be reduced if more diesel fuel were produced relative to gasoline; methanol-gasoline blends seem to offer no distinct advantage over gasoline thus far; engines that do not impose specific requirements on the chemical structure of their fuel would be likely to face fewer problems with energy availability than those demanding specific fuel characteristics; and the capacity for electric power generation is not likely to be a constraining factor in the rate of introduction of electric cars.

by C. L. Hamilton; K. L. Heitner; S. D. Foulkes  
California Inst. of Tech., Jet Propulsion Lab.  
Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a New Engine? Vol. 2, Pasadena, 1975 p17-1-17-37  
1975 ; 37p 45refs  
Availability: In HS-018 082

HS-018 099

## MATERIAL RESOURCE REQUIREMENTS AND SUPPLY

The material resources required to produce alternate-engined automotive vehicles are evaluated. The following areas of concern are discussed: the energy versus the materials crisis; the substitutability of materials; current automobile materials usage; materials requirements for alternate engines; the potential to reduce automotive demand for materials (potential to reduce materials usage, and the recycling of materials); the potential to increase the supply of materials; increasing the supply of specific key materials (nickel, chromium, cobalt, and tungsten); and policy factors affecting the supply and demand of materials. A variety of statistics are presented on: materials consumption by weight and type; alternate engines weight and material requirements; and world production and reserves and United States consumption of the specific materials mentioned above.

by W. A. Edmiston  
California Inst. of Tech., Jet Propulsion Lab.  
Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a New Engine? Vol. 2, Pasadena, 1975 p18-1-18-31  
1975 ; 31p 20refs  
Availability: In HS-018 082

HS-018 100

## AIR QUALITY IMPACT STUDY

The impact of mass introduction of alternative engines on urban air quality is considered. The present air pollution problem in urban areas is reviewed and statistics on maximum 1972 pollutant concentrations and the contribution of light duty vehicle emissions to pollution (1970-1973) in 10 major United States metropolitan areas are presented. Three cities, New York, Los Angeles, and St. Louis, were chosen for detailed study. The level of allowable emissions was estimated for each region, projected emissions into the 1980's were obtained, and the total light-duty-vehicle emissions for a future year were calculated. Air quality data, required emission reduction, emission inventory and projection, and emission control strategies for each of the cities are discussed. It is concluded that: to meet the present air quality standard for carbon monoxide (CO) the statutory auto emission standard of 3.4 grams per mile CO is adequate through 1990; the air quality of the photochemical oxidants can be significantly improved nation-



wide with a moderate auto-exhaust hydrocarbon emission standard; to meet the present national air quality standard for nitrogen dioxide (NO<sub>2</sub>), an automobile emission level of 2 grams per mile oxides of nitrogen is adequate for almost all regions except Los Angeles; the light-duty vehicle emission standards discussed here are expected to improve CO, NO<sub>2</sub> and oxidant air quality significantly throughout the nation in the 1980-1990 period; any engine with which the car can meet the stated emission standards is compatible with urban air quality requirements through 1990; legislation of suitable particulate emission standards is recommended; the sulfur content in automotive fuels should be restricted; and it is important to be alert to new types of air pollution problems.

by T. C. K. Peng

California Inst. of Tech., Jet Propulsion Lab.

Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a New Engine? Vol. 2, Pasadena, 1975 p19-1--19-42  
1975 ; 42p 55refs

Availability: In HS-018 082

HS-018 101

### **OWNERSHIP COSTS AND ECONOMIC IMPACT**

The effects of changes in automobile ownership costs to the consumer with the introduction of new engine technology are investigated: the purchase and operating costs of an automobile with various engines are derived; the effect of alternate engines on auto industry production and labor dislocation is discussed; and potential impacts on import requirements are evaluated. It is concluded that: potential savings in the present values of operating costs can exceed the initial cost differences of the alternate engines in just a few years; the Stirling-engined vehicles deliver the best fuel economy, while the Brayton-engined vehicles can be produced at the lowest cost; it is likely that these engines can be marketed without support from the government and yet maintain or better the dollar volume of auto sales; there should be no adverse effect on the nation's economy; and the increase in foreign payments for raw materials for the new engines would be trivial compared to the potential savings in oil import costs.

by T. C. K. Peng

California Inst. of Tech., Jet Propulsion Lab.

Publ: HS-018 082 (JPL-SP-43-17-Vol-2), Should We Have a New Engine? Vol. 2, Pasadena, 1975 p20-1--20-20  
1975 ; 42p 11refs

Availability: In HS-018 082

HS-018 102

### **STAPP CAR CRASH CONFERENCE (19TH) PROCEEDINGS, NOVEMBER 17-19, 1975, SAN DIEGO, CALIF.**

Discussions of the following topics are presented: a comparison between the belt-induced injuries of laboratory surrogates and real world accident victims; an efficiency comparison between a three-point belt and an air bag in a subcompact vehicle; the 1973 and 1974 passenger car injury patterns by restraint usage; the injury to unembalmed belted cadavers in simulated collisions; the impact behavior of the Hybrid II dummy; comparison of in-field and reconstructed accidents with dummies and cadavers; the crash effects to the thoraxes of three point belt wearers (cadavers); neck and thorax tolerance levels of belt-protected occupants in head-on collisions;

cadaver skeletal response to blunt thoracic impact; and the prediction of thoracic injury from dummy responses. Also discussed are: frontal crash evaluation tests of a five-point harness child restraint; evaluation of child dummy and baboon performances in child restraint systems in a systemized crash; computerized car-to-car side impacts; the biomechanical properties of the human neck in lateral flexion; the effect of the initial position of the head and neck on their dynamic response to impact acceleration; the static bending response of the human lower torso; the impact response and tolerance of the lower extremities; cadaver femur responses to longitudinal impacts; the transient structural response of the linear skull-brain system; the use of head injury criteria in protective headgear evaluation; the development of a brain model; head space requirements for seat belt wearers; pedestrian-vehicle accident simulation using dummies; and reducing pedestrian injury by vehicle design. In addition, the following topics are discussed: the effect of variable load energy absorbers on the biodynamic response of cadavers; the significance of onset rate in impact injury evaluation; front passenger passive restraint for small car, high speed, frontal impacts; injury predictions for frontal collisions; dynamic spinal response during acceleration; an experimentally validated 3-dimensional inertial tracking package for application in biodynamic research; the primate as a model for crash injury; and the contribution of physical accident analysis towards interpretation of severe accident trauma.

Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pa. 15096

Rept. No. SAE-P-62 ; 1975 ; 980p refs

Includes HS-018 103--HS-018 137. Sponsored by the University of California at Los Angeles, Wayne State Univ., University of Michigan, Hwy. Safety Res. Inst., and the Society of Automotive Engineers, Inc.

Availability: SAE

HS-018 103

### **THREE-POINT BELT INDUCED INJURIES: A COMPARISON BETWEEN LABORATORY SURROGATES AND REAL WORLD ACCIDENT VICTIMS**

Injuries produced by standard three point restraint systems with retractors were examined in five sled impacts of a 1972 full sized passenger car at 30 mph using five belted male cadavers (average age 58.2 years). Injury data from a national sample of real world frontal collisions of 1973-1975 full-sized cars (from an accident file including 5971 vehicles with 8260 occupants) were also studied. Cadaver tests resulted in extremely severe thoracic and cervical injuries, including multiple rib fractures, fractures of the sternum, clavicle and cervical vertebrae. It was found that such injuries in real world crashes of equivalent severity are not always observed. The reasons possible for these differences are discussed.

by J. Robert Cromack; H. Haskell Ziperman

Southwest Res. Inst.

Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p1-24

Rept. No. SAE-751141 ; 1975 ; 8refs

Conference held in San Diego, 17-19 Nov 1975. Research funded by the National Hwy. Traffic Safety Administration.  
Availability: In HS-018 102

HS-018 104

### EFFICIENCY COMPARISON BETWEEN THREE-POINT BELT AND AIR BAG IN A SUBCOMPACT VEHICLE

The protection efficiency of three point belt and air bag restraint systems under various crash conditions is compared. Dynamic tests were performed with subcompact vehicles (Renault R 12's) in which two dummies were restrained, either by three point belts with load limiting devices or by air bags consisting of solid gas generators and bags including porous outlets (the driver's knees were protected by a collapsible structure). Three types of crashes were chosen: frontal barrier crash at 50 kilometers per hour (km/hr); head-on crash between two vehicles with overlap at 50 km/hr; and crash against a guardrail at 80 km/hr with a 30 degree angle of impact. The comparison drawn from commonly used biomechanical indices shows that the three point belt ensures a protection in each analyzed crash type but it should be improved in order to reduce head deceleration. The air bag results depend on the crash type and show the problems of adaptation in a subcompact vehicle. The frontal barrier crash tests conducted with another type of dummy reveal that the results obtained for the two restraint types depend on the dummy, so that the efficiency assessment is difficult.

by M. Dejeannes; R. Quincy  
Organisme National de Sécurité Routière (Onser), Laboratoire des Chocs, France  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p25-44  
Rept. No. SAE-751142; 1975; 12refs  
Conference held in San Diego, 17-19 Nov 1975. Supported by the French Hwy. Administration. Technical aids supplied by the Society Renault and the Society SNPE.  
Availability: In HS-018 102

HS-018 105

### INJURY PATTERNS BY RESTRAINT USAGE IN 1973 AND 1974 PASSENGER CARS

Data on towaway accidents involving 1973 and 1974 American passenger cars were collected according to a systematic sampling plan of police-reported accidents in order to measure 1974 restraint system performance. The data on 5,138 drivers and right front passengers were collected nationwide. Analysis showed that the 1974 ignition interlock system increased full restraint system usage by a factor of 10 over 1973 cars. The 1974 full restraint system (lap and upper-torso belts) also demonstrated a greater reduction in severe injuries than the 1973 lap-belt-only system. Little reduction in 1974 severe injuries was found when the two model years were compared. Injury patterns were explored in terms of the rate of occurrence of specific injuries by body region, lesion, and injury source. All restrained occupants sustained a lower rate of specific injuries than unbelted occupants, and fully restrained occupants had a greater probability of receiving fewer injuries than lap-belted occupants. Restrained occupants received fewer head, face, extremity, and chest injuries and more neck, abdomen, and pelvis injuries. The rate of face injuries with full restraints was half the rate of lap-belt-only occupants. Full restraints also reduced the incidence of steering-assembly and front-injury injuries but did not eliminate them.

by Joseph C. Marsh; R. E. Scott; John W. Melvin  
University of Michigan, Hwy. Safety Res. Inst.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p45-78  
Rept. No. SAE-751143; 1975; 9refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 106

### INJURY TO UNEMBALMED BELTED CADAVERS IN SIMULATED COLLISIONS

Unembalmed cadavers restrained with three-point harnesses were exposed to a deceleration environment of 20, 30, and 40 mph in barrier equivalent collision simulations. Injuries were tabulated from detailed autopsies. The results indicate an Abbreviated Injury Scale level 1 (AIS 1) injury at 25.5 mph, an AIS-2 injury at 31.5 mph, and an AIS-3 injury at 34.5 mph. The AIS-3 is recommended as the maximum acceptable injury level. The cadavers sustained the same types of injuries that have been reported in medical literature including bruises, abrasions, lacerations, fractures and viscera ruptures, but injury severities were greater in the cadavers than in living humans at a given collision severity. Also, there is a wide spread in the degree of injury between cadavers due to differences in age and physical condition. The threshold of cadaver rib fracture was 30 mph and the threshold of cadaver vertebral fracture was between 30 and 40 mph. More numerous and severe abdominal injuries were observed. They were attributed to excessive submaning as a result of no restraint from the instrument panel and leg muscles of the cadaver. It is concluded that the cadaver is an excellent means of studying the types of injuries to be expected from a collision environment.

by L. M. Patrick; R. S. Levine  
Wayne State Univ.  
Contract DOT-HS-146-3-753  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p79-115  
Rept. No. SAE-751144; 1975; 25refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 107

### THE IMPACT BEHAVIOR OF THE HYBRID II DUMMY

The head, chest and femurs of three Hybrid II dummies were impacted with a ballistic pendulum at various angles (30, 60, 120, 150, 180, 270, and 330 degrees) to determine what differences in accelerometer and femur load cell output would result for a constant energy input. Also evaluated were suspicious tension loads in the femur load cell output when the legs were subjected to obvious off-center impacts during sled crash tests. It was found that the dummy legs can be subjected to very high torsion and bending loads which can have a significant effect on the femur load cell axial load outputs.

by Roger P. Daniel; Kenneth R. Trosien; Burgess O. Young  
Ford Motor Co.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p117-37  
Rept. No. SAE-751145; 1975; 1ref  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 108

# **MOTION SEQUENCE CRITERIA AND DESIGN PROPOSALS FOR RESTRAINT DEVICES IN ORDER TO AVOID UNFAVORABLE BIOMECHANIC CONDITIONS AND SUBMARINING**

The importance of a controlled motion sequence for the belted passenger in a collision situation is shown: only biomechanically optimal conditions of restraint force application offer the prerequisites necessary for getting the best out of the present biomechanical tolerance limits. First results of current belt accident investigations demonstrate that the lack of controlled motion is a problem. Supplements and modifications of safety standards are seen as the only effective method of speeding up improvements on the belt-seat system. Motion sequence criteria and design specifications are suggested as improvements. One possible belt-restraint-seat design is introduced with its favorable biomechanical properties. Partial sled test results explain the use and the effectiveness of the required ranges of the criteria of the motion sequence.

by Dieter Adomeit; Alfred Heger  
Technische Universität, Inst. of Automotive Engineering,  
Berlin  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p139-65  
Rept. No. SAE-751146; 1975; 7refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 109

# **COMPARISON BETWEEN IN-THE-FIELD ACCIDENTS AND RECONSTRUCTED ACCIDENTS WITH DUMMIES AND WITH CADAVERS**

Two real world accidents are compared to their reconstructions with dummies and cadavers as occupants. The first accident was a frontal collision between a 1971 Simca 1100 and a 1973 Citroen GS 1220 Sedan at an estimated relative speed of 68.4 mph. The two occupants of the Citroen were restrained with standard three-point belts and survived the crash. The three occupants of the Simca were unrestrained and two died as a result of their injuries. The second accident was a frontal collision between a 1973 Renault R5 TL and a 1973 GS Citroen 1120 Sedan at an estimated impact speed of 52.8 mph. The occupants of both cars were restrained and all survived. Results show that it is possible to reconstruct well-documented accidents. In frontal impacts cadavers seem to correctly simulate safety belt restrained living occupants. The chest response, in terms of resultant acceleration and severity index is comparable between dummies and cadavers. The severity of chest injuries, especially rib fractures, seems to be increased for cadavers as compared to living occupants in the real accidents. There are many differences in head responses between cadavers and dummies. The cadavers did not allow study of intracranial injuries so it was not realistic to find head tolerance levels by this method. Also, there is no agreement between the head injuries sustained in actual accidents and the Head Injury Criteria values calculated from head dummy accelerations.

by D. Cesari; M. Ramet  
Organisme National de Sécurité Routière (Onser), Laboratoire des Chocs et de Biomécanique, France  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p167-93  
Rept. No. SAE-751147; 1975; 10refs  
Conference held in San Diego, 17-19 Nov 1975. Supported by the French Ministère de l'Équipement et du Logement, Direction des routes et de la Sécurité Routière. Prepared in cooperation with Societe Anonyme des Automobiles CITROEN, Renault, and Chrysler France.  
Availability: In HS-018 102

HS-018 110

# **THORAX OF 3-POINT BELT WEARERS DURING A CRASH (EXPERIMENTS WITH CADAVERS)**

The results of frontal crash simulation tests on the thoraxes of cadavers wearing 3-point safety belts are presented. A total of 31 cadavers were subjected to dynamic sled tests and 7 to static tests. Cadaver preparation is discussed and skeleton strength is characterized. The results of the thorax autopsies, the corresponding seat belt restraint forces, some measurements with dummies used simultaneously, and some data on recorded thorax deflections are included. Injuries observed from the autopsies are compared with the measurements (forces, accelerations, deflections) made on cadavers and dummies, and with previously published data. The difference between tolerance to impact and to belt forces is pointed out. Data helpful in defining a dummy thorax are included.

by A. Fayon; C. Tarriere; G. Walfisch; C. Got; A. Patel  
Peugeot-Renault, Lab. of Biomechanics and Physiology; I.R.O., Raymond Poincaré Hosp., Garches  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p195-223  
Rept. No. SAE-751148; 1975; 13refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 111

# **NECK AND THORAX TOLERANCE LEVELS OF BELT-PROTECTED OCCUPANTS IN HEAD-ON COLLISIONS**

The results of 103 tests of neck and thorax tolerance levels for belt-protected occupants in head-on collisions are presented. The following restraints were used in the tests: 3-point standard belt with automatic retractor at 30, 40, and 50 kilometers per hour (km/hr); 2-point diagonal shoulder belt with automatic retractor at 30, 40 and 50 km/hr; 2-point diagonal shoulder belt with automatic retractor and kneebar at 50 km/hr; and three-point belt with broader surface at 50 km/hr. Tests were made with human cadavers of both sexes and from 12 to 82 years old. Two high speed cameras documented the impact phases. While the severity of injuries showed an increase with advancing age, it is not obviously dependent upon weight or sex. The 12 to 30 year old age group reached the thorax tolerance level at an impact velocity of still below 50 km/hr with a stopping distance of 40 centimeters, the 30 to 50 year old age group of below 40 km/hr, and the age group beyond 50 years below 30 km/hr. Results are compared with volunteer tests, evaluated real accidents, and similar cadaver tests.

by G. Schmidt; D. Kallieris; J. Barz; R. Mattern; J. Klaiber  
University of Heidelberg, West Germany  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p225-57  
Rept. No. SAE-751149; 1975; 3 refs.  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

## HS-018 112

### CADAVER SKELETAL RESPONSE TO BLUNT THORACIC IMPACT

The results of analyses performed upon the sternal and acceleration-time response data for blunt thoracic impacts from experiments with 18 cadavers, aged 46 to 75, are presented. Accelerometer and transducer mounting procedures are explained. For those experiments with only sternal data available, the following plots are presented: the entire acceleration-time history; the Gadd Severity Index as a function of time; the calculated sternal velocity and displacement as a function of time; and the initial spike pulse displayed on a greatly expanded time base. Where there are only spinal data, spinal responses corresponding to the above items are presented, and when both types of data are available, both sets of responses are given. High acceleration levels, rates of onset, and Gadd Severity Indices were found in sternal acceleration measurements, whereas quite low values were obtained from the spinal regions in the same tests. A Severity Index value of 1000 would be associated with only a mild exposure; whereas for a spinal measurement, the same value would reflect an extremely severe exposure. None of the sternal acceleration parameters were found to correlate well with Abbreviated Injury Scale (AIS) ratings. Maximum spinal velocity and spinal Severity Index both indicate good correlations with AIS rating; but because of an obvious dependence on the degree of body restraint, they are regarded as less broadly applicable and less useful than normalized chest deflection for the indication of the severity of thoracic impact exposure.

by Alan M. Nahum; Dennis C. Schneider; Charles K. Kroell  
University of California, Dept. of Surgery, San Diego; General Motors Res. Labs., Biomedical Science Dept.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p259-93  
Rept. No. SAE-751150; 1975; 7 refs.  
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## HS-018 113

### PREDICTION OF THORACIC INJURY FROM DUMMY RESPONSES

Currently used criteria based on functions of spinal acceleration obtained from crash test dummies are shown to be invalid indicators of chest injury in blunt frontal impacts. Cadaver impact data are analyzed; and injury is found to be a statistically significant function of chest deflection, chest depth, and cadaver age at death. Based on the resulting regression equations, injury-limiting chest deflections are recommended for various size test dummies. The recommendations apply only to test dummies that have significant thoracic biofidelity for blunt frontal impact. They are valid for environments which include significant blunt frontal impact. Their extension to other environments has not been validated.

by Raymond F. Neathery; Charles K. Kroell; Harold J. Mertz  
General Motors Res. Labs., Biomedical Science Dept.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p293-316  
Rept. No. SAE-751151; 1975; 21 refs.  
Conference held in San Diego, 17-19 Nov 1975.  
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## HS-018 114

### FRONTAL CRASH EVALUATION TESTS OF A FIVE-POINT HARNESS CHILD RESTRAINT

Tests were conducted to provide information on the mechanics of child restraint with a five-point harness system. For anatomical reasons, juvenile chimpanzees were chosen as the best approximation of the human child. Sedated juvenile male chimpanzees withstood frontal deceleration tests in a five-point harness at crash speeds of 20, 25, and 30 mph without skeletal bone fractures or evidence of soft tissue injury. Injury assessment was by X-ray and blood serum enzyme analysis as well as electrocardiogram readings and post-test observations of the animal's behavior. While the animal model used does not fully guarantee the identical performance of the harness system with humans, these results add additional weight to the opinion that the protection offered the child seat occupant is comparable to that available to adult passengers by the conventional three-point restraint system.

by Richard M. Schreck; Lawrence M. Patrick  
General Motors Res. Labs., Biomedical Science Dept.; Wayne State Univ., Biomechanics Res. Center  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p317-43  
Rept. No. SAE-751152; 1975; 18 refs.  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

## HS-018 115

### PERFORMANCE EVALUATION OF CHILD DUMMIES AND BABOONS IN CHILD RESTRAINT SYSTEMS IN A SYSTEMATIZED CRASH ENVIRONMENT

A three-part program, undertaken to establish an appropriate means of evaluating child restraints in car crashes, is described. A standard seat was designed to provide a reproducible test base on which to evaluate child restraint systems in dynamic testing. Developmental and evaluation data are presented, including child restraint performance tests. Results showed the standard seat to be a durable, repeatable, and economical test platform which provides a realistic base for evaluation of child restraint systems. Commercially available three and six year old child dummies were evaluated for their anthropometric measurements and dynamic response characteristics in pendulum impact tests and simulated crashes in representative automobile-child seat restraint environments. Simulated crashes included 20 and 30 mph frontal and 20 mph side impacts on automobile and specially designed bench seats. Two types of child seats, the General Motors "Love Seat" and Chrysler "Mopar," were selected for testing as representative of belt and padding restraint types currently in use. The three year old child dummies were found capable of providing repeatable measurements of the head and chest accelerations and head deflections in sled tests. Acceleration measurements on both six year old child dummies were found to contain cer-

tain resonances. It was also found that the dummy consisting of clearly defined adjustable body segments is a better simulator than the lumped mass unadjustable type. Test results also indicate that current instrumentation technology for application to living subjects is not adequately developed to permit consistent measurements in terms of g levels and injury criteria. The tested shield-type child restraint (Ford Tot-Guard) exposed the occupant to potential risk of ejection during the rebound mode of the forward-collision phase and to substantial excursion in lateral collisions if the seat does not have provisions for limiting the lateral motion of the test subject.

by Stanley H. Backaitis; Jere W. Medlin, Jr.; Vladislav G. Radovich; Richard L. Stalnaker; Mahesh P. Shah; John T. Shaffer; Robert M. Letscher  
National Hwy. Traffic Safety Administration; University of Michigan, Hwy. Safety Res. Inst.; Transportation Res. Center; 6570th Aerospace Med. Res. Lab.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p345-403  
Rept. No. SAE-751153 ; 1975 ; 4refs  
Part titles: pt. 1, Development of a Standard Bench Vehicle Seat; pt. 2, Performance Evaluation of Child Dummies; and pt. 3, Comparison of Kinematic Response Baboons and Child Dummies. Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 116

### **CAR-TO-CAR SIDE IMPACTS: COMPUTERIZED CRASH RECONSTRUCTION**

The injury relations resulting when car-to-car crashes are analyzed using a computerized accident reconstruction procedure are described. Results are presented in the form of graphical relations between injury and crash severity. Effects of factors such as impact location, seating position, and vehicle weights are discussed. The reconstruction of side impact collisions involving two passenger vehicles is the main concern of the study. A methodology is developed for data analysis and a relation between crash severity and injury causation is formulated. Results are based on only 49 cases from the Multidisciplinary Accident Investigation file, so that definitive statistical conclusions are not possible. Patterns, however, are apparent and suggest relations between accident parameters and occupant injuries. These are discussed and interpreted.

by August L. Burgett; Michael W. Monk  
National Hwy. Traffic Safety Administration  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p405-27  
Rept. No. SAE-751154 ; 1975 ; 9refs  
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HS-018 117

### **SIMULATED OCCUPANT RESPONSE TO SIDE-IMPACT COLLISIONS**

Occupant response to side-impact collisions is studied with a mathematical vehicle/occupant model to investigate head-torso relative motion and neck forces and moments. Computer simulations were performed in conjunction with a study on properties of the neck in lateral motion involving 96 subjects divided into groups by age and sex (18-24 years, 35-44 years, and 62-74 years old, male and female). Subject data were collected on head-neck lateral bend range of motion, sternomastoid muscle

group strength, reflex time, and anthropometry. For the various subject groups, the series of computer simulations investigated 10 and 30 mph car-to-car impacts, the effect of muscle reflex with muscle tension buildup, and the effect of varying degrees of pre-impact constant tension. It is determined that neck muscle contraction may significantly lessen the likelihood of hard tissue injury resulting from excessive lateral flexion. The lesser muscular strength of female and elderly crash victims indicates greater susceptibility to neck injury for these groups.

by B. M. Bowman; L. W. Schneider; D. R. Foust  
University of Michigan, Hwy. Safety Res. Inst.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p429-54  
Rept. No. SAE-751155 ; 1975 ; 18refs  
Conference held in San Diego, 17-19 Nov 1975. Sponsored by the Insurance Inst. for Hwy. Safety, Washington, D.C.  
Availability: In HS-018 102

HS-018 118

### **BIOMECHANICAL PROPERTIES OF THE HUMAN NECK IN LATERAL FLEXION**

Properties of the human neck which may influence a person's susceptibility to "whiplash" injury during lateral impact have been studied in 96 normal subjects. Subjects were chosen on the basis of age, sex and stature and data were grouped into six primary categories based on sex and age (18-24, 35-44, and 62-74 years old). The data include: measures of head, neck, and body anthropometry in standing and simulated automotive seating positions, three-dimensional range of motion of the head and neck, head/neck response to low-level acceleration, and both strength reflex time and voluntary isometric muscle force in the lateral direction. Reflex times are found to vary from about 30 to 70 milliseconds with young and middle aged persons having faster times than older persons and females having faster times than males. Muscle strength decreases with age, and men are, on the average, stronger than females. Range of motion was determined by using three dimensional photogrammetry and reported for six planar movements (flexion, extension, left and right rotation, left and right lateral bend) and three combination movements (left rotation plus flexion, left rotation plus left lateral bend, and right rotation plus extension) chosen to simulate typical lateral impact conditions. In all cases, the range of motion decreases with age, with the rate of decrease greater for males than for females. Data are presented in a format applicable to biomechanical modeling of the seated human occupant.

by Lawrence W. Schneider; David R. Foust; Bruce M. Bowman; Richard G. Snyder; Don B. Chaffin; Thomas A. Abdelnour; Janet K. Baum  
University of Michigan  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p455-85  
Rept. No. SAE-751156 ; 1975 ; 7refs  
Conference held in San Diego, 17-19 Nov 1975. Sponsored by the Insurance Inst. for Hwy. Safety, Washington, D.C.  
Availability: In HS-018 102

HS-018 119

### **THE EFFECT OF THE INITIAL POSITION OF THE HEAD AND NECK ON THE DYNAMIC RESPONSE**

## OF THE HUMAN HEAD AND NECK TO -GX IMPACT ACCELERATION

Thirteen human volunteers ranging from the 5th to the 97th percentile in sitting height were exposed to impact acceleration at peak sled accelerations of 6g and 10g. Two angles of the neck relative to chair and two angles of the head relative to the neck were tested for each subject for the two peak acceleration levels giving a total of 104 experiments. Instrumentation consisted of six accelerometers and a two-axis rate gyro at the posterior spinous process of the first thoracic vertebral body, six accelerometers at the mouth, and a two-axis rate gyro at the top of the head. Three-dimensional photography from two orthogonally mounted onboard cameras was used also.

by C. L. Ewing; D. J. Thomas; L. Lustick; E. Becker; G. Willems; W. H. Muzzy, 3rd  
Naval Aerospace Medical Res. Lab. Detachment  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p487-512  
Rept. No. SAE-751157; 1975; 12refs  
Conference held in San Diego, 17-19 Nov 1975. Supported by the Naval Medical Res. and Devel. Command; Office of Naval Res., Biological Sciences Div. and the Army Medical Res. and Devel. Command.  
Availability: In HS-018 102

HS-018 120

## STATIC BENDING RESPONSE OF THE HUMAN LOWER TORSO

Quasi-static bending response characteristics of the lower torso are defined. Six male volunteers, selected to provide a range in height and weight, were subjected to a total of 72 tests to define response characteristics for sagittal flexion and extension bending. The effects of muscle tension and knee bend on the response are evaluated. Sixteen loading corridors of moment of applied force about hip-point axis versus thorax-pelvis and pelvis-femur angles are suggested. Subject preparation and the bending test fixture are described. It was found that the relaxed and tensed lower torso bending responses are significantly different from one another. The basic shapes of the loading corridors are not the same.

by Gerald W. Nyquist; Clarence J. Murton  
General Motors Res. Labs., Biomedical Science Dept.; Wayne State Univ., Biomechanics Res. Center  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p513-41  
Rept. No. SAE-751158; 1975; 3refs  
Conference held in San Diego, 17-19 Nov 1975. Prepared with the assistance of L. M. Patrick and Roger Culver.  
Availability: In HS-018 102

HS-018 121

## IMPACT RESPONSE AND TOLERANCE OF THE LOWER EXTREMITIES

The results of direct impact tests and driving point impedance tests on the legs of seated cadavers are presented. Variables studied included impactor energy and impact direction (axial and oblique). Multiple strain gage rosettes were applied to the bone to determine the strain distribution in the bone. Results indicate that the unembalmed skeletal system of the lower extremities is capable of carrying significantly greater loads than

those determined in tests with embalmed subjects. Strain analysis indicated that significant bending moments are generated in the femur with axial knee impact. Results of impedance testing are used to characterize the load transmission behavior of the knee-femur-pelvis complex, and the impact test results are combined with this information to produce suggested response characteristics for dummy simulation of knee impact response.

by John W. Melvin; Richard L. Stalnaker; Nabih M. Alem; Joseph B. Benson; Dinesh Mohan  
University of Michigan, Hwy. Safety Res. Inst.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p543-59  
Rept. No. SAE-751159; 1975; 8refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 122

## CADAVER FEMUR RESPONSES TO LONGITUDINAL IMPACTS

Results from longitudinal impact tests on the knees of nine seated adult cadavers equipped with strain gages are reported. Typical impact velocities, impact force histories and femur strain histories are presented. The importance of femur bending is revealed by strain readings on the medial, lateral, anterior and posterior surfaces. The effects of impactor padding, leg tissue and oblique impacts are illustrated. The average fracture force level was found to be 10.04 kN and the impact energy to be 549J. The fracture patterns and possible mechanisms are discussed.

by William R. Powell; Steven J. Ojala; Sunder H. Advani; R. Bruce Martin  
Brace Virginia Univ.  
Contract NIH-NO-1-NS-4-2302  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p561-79  
Rept. No. SAE-751160; 1975; 11refs  
Conference held in San Diego, 17-19 Nov 1975. Support and advice provided by the National Hwy. Traffic Safety Administration.  
Availability: In HS-018 102

HS-018 123

## TRANSIENT STRUCTURAL RESPONSE OF THE LINEAR SKULL-BRAIN SYSTEM

The results of a head injury model development program are presented. Included is a description of the model's features and its capabilities for simulating direct and indirect impact forces. The model's validity is discussed in terms of level of confidence and verification. Skull bone response and brain response are presented for a variety of dynamic simulations. The scope and limitations imposed by the assumption of linearity are discussed. Results demonstrate that while some minor changes appear, indicated, the model predictions yield useful insight into the mechanical causes of skull and brain injury.

by T. A. Shugart  
Civil Engineering Lab., NCSCB  
Contract DOT-HS-289-3-510-A  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p581-614  
Rept. No. SAE-751161; 1975; 20refs  
Conference held in San Diego, 17-19 Nov 1975. Additional  
funding from the Naval Aerospace Medical Res. Lab.,  
Michoud Station, New Orleans.  
Availability: In HS-018 102

HS-018 124

## **ON THE USE OF THE HEAD INJURY CRITERION (HIC) IN PROTECTIVE HEADGEAR EVALUATION**

The validity and appropriateness of the application of the Head Injury Criterion concept to motorcycle helmet testing is examined. Its derivation is reviewed and its logic assessed. It is shown to be an inconsistent and unreliable criterion for helmet performance evaluation. This inconsistency stems primarily from its poor correlation with experimental data and from the basic assumption that the seriousness of a head impact can be ascertained by considering only a portion of the test head-form acceleration pulse. Several alternative criteria which all are physically sound and mathematically consistent and which are more amenable to protective headgear design and testing are proposed. These criteria include force and loading time minimization; load distribution; minimization of loading rate; and maximization of energy dissipation.

by James A. Newman  
University of Ottawa, Mechanical Engineering, Canada  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p615-40  
Rept. No. SAE-751162; 1975; 42refs  
Conference held in San Diego, 17-19 Nov 1975. Supported by  
Bell Helms Inc., Long Beach, Calif.  
Availability: In HS-018 102

HS-018 125

## **THE DEVELOPMENT OF A DETAILED FINITE ELEMENT BRAIN MODEL**

A finite element model of the human brain providing badly needed new information and insight in brain dynamics is described. The model is based on fewer assumptions and has sufficient detail to permit correlation with experiments. Observations of 23 living subjects and 40 cadavers regarding the effect of head tilt on the medulla oblongata led to the following static correlation tests on cadavers: radiography, using silver pin markers placed in the brain stem and cervical cord; photography, using paper strip indicators mounted on the posterior side of the brain stem and cervical cord; and photographic examination of increased lateral dimensions. The model is seen to demonstrate a new approach to brain modeling and a useful tool in future research. A review of head injury research and the material properties of the human head are appended.

by Carley Conrad Ward; Robert B. Thompson  
Naval Construction Battalion Center, Civil Engineering Lab.  
Contract DOT-HS-5-01132  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p641-74  
Rept. No. SAE-751163; 1975; 48refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 126

## **HEAD SPACE REQUIREMENTS FOR SEAT BELT WEARERS**

Crash simulations were carried out in New South Wales, Australia to map the head dynamics of a three-point belted occupant in frontal and a range of side impacts in which no invasion or loss of head space occurs. The simulations employed a dummy with a very compliant thorax, modified with a stacked ball joint neck, this combination having been shown to closely reproduce head motion of human volunteers in frontal crashes reported in the literature. Validation of the dummy and an investigation of the influence on head space of the angle of impact, of inertial reels in shoulder straps, and of seat springing, in contrast to the hard seats used for the volunteer crashes, are discussed. Results provide evidence of the value of increasing head space so as to reduce the likelihood of head impact for otherwise well-restrained occupants of passenger cars. Three current model cars, a Holden LH Torana, a Chrysler Valiant, and an American Motors Matador, were tested for their availability of head space and were found to be lacking, especially in front corner impacts on the passenger's side of the car involving about 22 degrees impact yaw.

by David C. Herbert; John D. Stott; Christopher W. Corben  
Department of Motor Transport, Traffic Accident Res. Unit,  
N.S.W., Australia  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p675-704  
Rept. No. SAE-751164; 1975; 23refs  
Conference held in San Diego, 17-19 Nov 1975. Prepared with  
the assistance of Hal P. Walters, Department of  
Transportation, Occupant Restraint Systems Div.  
Availability: In HS-018 102

HS-018 127

## **PEDESTRIAN VEHICLE ACCIDENT SIMULATION THROUGH DUMMY TESTS**

A body force measuring test vehicle for vehicle-pedestrian impact testing has been developed. It is a deformable unit which simulates the stiffness and geometrical measurements of a vehicle front and is supported by load cells. The complete assembly is fixed on a very stiff chassis which allows measurement of the resulting impact forces by magnitude and direction during the impact. Two geometrical parameters, height and slope of the automobile hood, have been varied to see their influence on the impact severity. The front shape used was a rounded pontoon type similar to small European cars. The results of some 20 test runs with impacts of up to about 30 mph demonstrate that the described test installation is a useful research instrument to study the influence of the design parameters of the car front on the impact performance and to evaluate their effect on the injury mechanism more precisely.

by Martin Kramer  
Berlin Technical Univ., Inst. of Automotive Engineering  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p705-24  
Rept. No. SAE-751165; 1975; 8refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

## EXPERIMENTAL STUDY OF PEDESTRIAN INJURY MINIMIZATION THROUGH VEHICLE DESIGN

A series of 15 experimental vehicle-pedestrian (cadaver) impacts were conducted covering a speed range of 10-30 mph to pioneer the establishment of impact tolerance levels for the pelvis and legs of a standing pedestrian and to explore the ability of a few selected geometric and compliance modifications to the impacting vehicle to increase tolerable impact velocities. Dynamic data obtained included high-speed films and time histories of: bumper and hood edge forces; horizontal and vertical ground reaction forces; and pelvic acceleration. Resulting injuries were determined from examination of pre- and post-impact X-rays and detailed pathological dissections, and were assessed as to probable temporary total and permanent partial disabilities. Results included; injuries to the lower body of an adult pedestrian are strongly dependent upon vehicle design; the pedestrian leg injury mechanism is a complex dynamic event influenced significantly by both the bumper force and the ground friction force; and a threshold tolerance value of pelvic acceleration appears to exist, below which pelvic injuries do not occur.

by H. B. Fritz; C. R. Hassler; J. T. Herridge; E. B. Weis, Jr. Battelle, Columbus Labs.  
 Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p725-51  
 Rept. No. SAE-751166; 1975; 3refs  
 Conference held in San Diego, 17-19 Nov 1975.  
 Availability: In HS-018 102

## SIMULATION OF COLLISIONS BETWEEN PEDESTRIANS AND VEHICLES USING ADULT AND CHILD DUMMIES

Vehicle-pedestrian collisions are analyzed, in conjunction with a bidisciplinary pedestrian investigation, by simulating accidents using adult and child dummies. A series of experimental collisions were carried out at varying impact speeds (6-25 mph) with a sample of vehicles representative of the various front-end profiles of modern vehicles to study how these profiles affect the kinematics of the adult and child, and to define the risks of injury during the different phases of the accident. The degrees of severity of the impact against the vehicle and the ground are compared and head impact speeds analyzed. Countermeasures are proposed and an initial evaluation made using a cadaver.

by G. Stecherbatcheff; C. Tarriere; P. Duclos; A. Fayon; C. Got; A. Patel  
 Peugeot-Renault, Lab. of Physiology and Biomechanics; I.R.O., Raymond Poincare Hosp., Garches  
 Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p753-83  
 Rept. No. SAE-751167; 1975; 23refs  
 Conference held in San Diego, 17-19 Nov 1975. Research performed as part of the French Thematic Action Prog.  
 Availability: In HS-018 102

## THE EFFECT OF VARIABLE LOAD ENERGY ABSORBERS ON THE BIODYNAMIC RESPONSE OF CADAVERS

The following types of variable load energy absorbers were tested on a sled simulating a crash deceleration using instrumented, seated erect dummies and cadavers: the frangible type; the inverting type; the aluminum and steel curling types; the tearing type; the tapered folding type; and the tapered curling type. These absorbers were mechanical load limiting devices which attenuated the impact by the yielding or tearing of metals. Principal effects were to reduce the peak deceleration sustained by the occupant with the expected reduction in restraint forces. Constant load level energy absorbers were not used because they can easily "bottom out," causing forces and body strains much higher than those without absorbers. Head accelerations were significantly reduced by the energy absorbers as well as some body strain. Spinal strains in the cadaver were not significantly reduced; they appear to be not only a function of the peak deceleration level but also of the duration of the pulse.

by Paul C. Begeman; Albert I. King  
 Wayne State Univ.  
 Contract N00014-75-C-1015 Grant NIH-5-K04-GM-21145-04  
 Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p787-806  
 Rept. No. SAE-751168; 1975; 8refs  
 Conference held in San Diego, 17-19 Nov 1975.  
 Availability: In HS-018 102

## SIGNIFICANCE OF RATE OF ONSET IN IMPACT INJURY EVALUATION

The concept of rate of onset as an injury potential index is critically discussed through the analysis of a wide range of noninjurious whole body decelerations and localized impacts. Examination of the physical data from past research shows that extremely high rates of onset are tolerable without injury and that these levels of rate of onset are reciprocally dependent on the pulse rise time. The physical data is discussed with reference to existing acceleration injury criteria, specifically the GSI and HIC indices. The idea is substantiated that a single rate of onset tolerance level is not warranted and that rate of onset is not a proven injury potential index.

by David C. Viano; Charles W. Gadd  
 General Motors Res. Labs., Biomedical Science Dept.  
 Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p807-19  
 Rept. No. SAE-751169; 1975; 15refs  
 Conference held in San Diego, 17-19 Nov 1975.  
 Availability: In HS-018 102

## FRONT PASSENGER PASSIVE RESTRAINT FOR SMALL CAR, HIGH SPEED, FRONTAL IMPACTS

A front passenger passive restraint system has been developed which provides frontal impact protection under small car, high



10, and 20 degrees has been used to develop this system for a range of occupant sizes including 6 year old child, 5th, 50th, and 95th percentile dummies. Computer simulations and static tests were also conducted. Observations regarding not only the performance but also the production feasibility and consumer acceptance of the system are presented. It is concluded that: the system appears capable of providing protection from fatality or serious injury to adult size occupants in a subcompact car at crash speeds up to 40 to 50 mph; the non-deployed system (bolster and knee bar only) can provide significant protection to adult occupants; and the deploying system provides a much safer crash environment to small children than the non-deploying system provided the child is seated in a normal position.

by David J. Romeo  
Calspan Corp.  
Contract DOT-HS-4-00972  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p821-48  
Rept. No. SAE-751170; 1975; 6refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 133

### INJURY PREDICTIONS FOR FRONTAL COLLISIONS

The development and application of empirical equations relating vehicle damage as expressed by the Collision Deformation Code to occupant injury as expressed by the Abbreviated Injury Scale are discussed. Only frontal collisions are dealt with. Different equations for unrestrained, seat belt restrained, and three-point belt restrained front seat occupants are presented. A brief comparison is also made between the actual injuries sustained by crash victims (using data from 33 cases with 47 victims) restrained by air cushions and the injuries predicted for occupants restrained by three-point belts in similar collision configurations.

by L. G. Watson; A. C. Shiels  
University of Saskatchewan, Transportation Centre  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p849-68  
Rept. No. SAE-751171; 1975; 4refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 134

### DYNAMIC RESPONSE OF THE SPINE DURING °GZ ACCELERATION

A 78 degree-of-freedom model of the spine, head, and pelvis which has already been validated in °Gz and -Gx acceleration directions is presented. Restraint systems, seat back, and seat cushions are considered. In this model, the torso is free to slide up the seat back. Results of simulation runs show a good correlation with the existing data and experimental cadaveric runs (with an 170 pound unrestrained cadaver on a Volkswagen sled test buck) made with a high seat back (or head restraint) and low seat back. The effect of seat-back stiffness and the restraint system on the response of the head and spine is studied.

by P. Prasad; N. Mital; A. I. King; L. M. Patrick  
Wayne State Univ.  
Contract N00014-75-C-1015 Grant NIH-5-K04-GM-21145-04  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p869-97  
Rept. No. SAE-751172; 1975; 24refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 135

### AN EXPERIMENTALLY VALIDATED 3-D INERTIAL TRACKING PACKAGE FOR APPLICATION IN BIODYNAMIC RESEARCH

A six-accelerometer inertial tracking package currently in intensive use in measuring living human and human surrogate response to impact acceleration is presented and discussed. Included is an enumeration of the various requirements imposed upon the package as well as its design and fabrication. The on-site calibration facility is described, including a discussion of the procedures for routine calibration of the packages. Accounts of the data acquisition link from the packages through the sled borne amplifiers to the hybrid computer are also included. Particular attention is devoted to the theoretical aspects of this system. A statement of errors is developed and compared to the various precision parameters of this system and to a general estimation of the dynamic response envelope demonstrating the overall feasibility of this approach.

by E. Becker; G. Willems  
Naval Aerospace Medical Res. Lab. Detachment  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference (19th) Proceedings, Warrendale, Pa., 1975, p899-930  
Rept. No. SAE-751173; 1975; 13refs  
Conference held in San Diego, 17-19 Nov 1975. Funded by the Naval Medical Res. and Devel. Command and the Biological Sciences Div. of the Office of Naval Res.  
Availability: In HS-018 102

HS-018 136

### THE PRIMATE AS A MODEL FOR CRASH INJURY

Anesthetized rhesus monkeys, baboons, and chimpanzees were subjected to a °Gz rectangular deceleration-time history (a 60 foot free fall in a 623 pound decelerator vehicle). The parameters of deceleration versus average time duration were plotted as a function of spinal trauma to produce a series of sensitivity curves based on spinal injury for three families of non-human primates. The locus, distribution, type, and severity of vertebral body fracture was distinguished on post-impact X-ray photographs. The primates were euthanized and the process of documenting and interpreting spinal trauma was repeated following necropsy and water maceration of the soft tissue. The mechanics of vertebral injury were identified. Normal skeletal geometry and proportionate torso kinesiology of the rhesus monkey, baboon and chimpanzee, and man were compared. The peculiarities and consistencies in injury distribution and their variations were interpreted in terms of distinctive vertebral morphology and functional kinesiology of each animal model. The distinguishing variations in injury patterns and their distribution were related to the scatter of human vertebral injury as reported in aircraft escape system accelerations, crash decelerations, and clinical statistics.

by Leon E. Kazarian  
Air Force Systems Command, 6570th Aerospace Medical Res.  
Lab., Wright-Patterson AFB, Ohio  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p931-63  
1975; 10refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-018 137

## THE CONTRIBUTION OF PHYSICAL ANALYSIS OF ACCIDENTS TOWARDS INTERPRETATION OF SEVERE TRAFFIC TRAUMA

Direct physical analysis of traffic accidents based on speed variation and the mean deceleration of the undistorted part of the vehicle for interpreting severe accident trauma is discussed. An attempt is made to show how the conventional method of estimating accident speed, called the "equivalent test speed," is a source of considerable errors for most accidents. Physical analysis is posed as the better method and a number of applications of the method are described.

by C. Tarriere; A. Fayon; F. Hartemann; P. Ventre  
Peugeot-Renault, Lab. of Physiology and Biomechanics;  
Renault Res. and Devel. Div.  
Publ: HS-018 102 (SAE-P-62), Stapp Car Crash Conference  
(19th) Proceedings, Warrendale, Pa., 1975, p965-93  
Rept. No. SAE-751176; 1975; 29refs  
Conference held in San Diego, 17-19 Nov 1975.  
Availability: In HS-018 102

HS-801 761

## STANDARDS ENFORCEMENT TEST REPORTS INDEX FOR 1974

Standards Enforcement Test Reports of the National Highway Traffic Safety Administration (NHTSA) released to the public during calendar year 1974 are indexed. The index is divided into 12 sections in which reports are categorized by: manufacturer, model year, model or part number, pass or fail, Federal Motor Vehicle Safety Standard number, component or vehicle identification (NHTSA number), laboratory test number, CIR number, fiscal year of test, HS number, brand or seller, and tire size or body style.

Kappa Systems, Inc., 1501 Wilson Blvd., Arlington, Va. 22209  
Contract ADP-3058  
1975; 1104p  
Sponsored by National Hwy. Traffic Safety Administration,  
Washington, D.C.  
Availability: NTIS

HS-801 765

## CHILD RESTRAINT ROLLOVER TEST DEVELOPMENT: FINAL TECHNICAL REPORT

The development of test equipment and procedures which will permit the evaluation of the protective potential of child restraint systems in the rollover environment is described. The test fixture, which was intended to become a prototype for compliance test use in conjunction with possible future rule-making activity, was to simulate the essential features of the rollover environment while providing repeatable inputs to the

restraint systems under test. Cost and relative simplicity of design were factors of major importance. An Alderson VIP-3C 3-year-old clothed dummy and an unclothed CAMI infant dummy were used in the tests. The test was defined as two revolutions of the test seat from the upright, with duration of the test being between 1.37 and 1.95 seconds. Notation was made of head excursion if violation of specified boundaries occurred. The mode of ejection, if it occurred, was noted. It is concluded that the general test procedure simulates several major features of the rollover environment at reasonable cost and offers unambiguous characterization of performance. It is recommended that a compliance-type rollover test fixture include instrumentation for angular velocity and head excursion. On-board high-speed photographic coverage is highly recommended as an aid to interpretation of test results. Consideration should be given to rotation of the test fixture in both directions in order to better simulate actual crash conditions. Restraint straps should be adjusted before test to a no-slack condition, but without additional tension. Dummy clothing was found to be an important variable of the test and should be standardized. Dummy joints are recommended to be set completely loose to best simulate the likely occurrence of a sleeping child. Shoulder structure of the test dummy and fit of the restraint harness to the dummy are important determinants of rollover test performance. Photographs of equipment, restraints, and tests are included.

by Mark P. Haffner; Claude H. Melton  
National Hwy. Traffic Safety Administration, Safety Res.  
Lab., 6501 Lafayette Ave., Bldg. 2, Riverdale, Md. 20840  
1975; 96p 17refs  
Report for Jul-Oct 1975.  
Availability: NTIS

HS-801 771

## FEASIBILITY STUDY OF PLASTIC AUTOMOTIVE STRUCTURE. FINAL REPORT

Reinforced plastics materials were studied to determine their feasibility in crashworthy structure design for a subcompact size automobile. Glass reinforced polyester and rigid polyurethane foam were selected as the primary materials of construction. Dynamic, 30 mph, drop tower tests were made on variously shaped test elements to determine the energy absorbing characteristics. A frontal structure was designed, fabricated, and subjected to a 50 mph flat barrier test, using a modified 1974 (Pinto) subcompact automobile. Some practical problems of the use of these reinforced plastic materials are discussed: mass production concepts, recyclability or disposal, flammability, reparability, energy considerations, and plastics cost and availability. It is concluded from the tests results that glass reinforced polyester materials could be used in a crashworthy automotive structure with a potential weight and cost savings. Discussions of the mechanical properties of reinforced plastics, and fiber glass/plastics repair are appended.

by Herbert A. Jahnle  
Budd Co., 300 Commerce Dr., Fort Washington, Pa. 19034  
Contract DOT-HS-4-00929  
Rept. No. TCR-0283-FR; 1975; 214p  
Rept. for Jun 1975-Aug 1975. For summary see HS-801 772.  
Availability: NTIS

HS-801 772

**FEASIBILITY STUDY OF PLASTIC AUTOMOTIVE STRUCTURE. SUMMARY REPORT**

by Herbert A. Jahnle  
Budd Co., 301 Commerce Dr., Fort Washington, Pa. 19034  
Contract DOT-HS-4-00929  
Rept. No. TCR-0283 ; 1975 ; 14p  
Rept. for Jun 1974-Aug 1975. For abstract see HS-801 771.  
Availability: NTIS

HS-801 773

**PIEZOELECTRIC POLYMER TRANSDUCER FOR IMPACT PRESSURE MEASUREMENT. FINAL REPORT**

Development efforts relating to the design, construction, and calibration of a piezoelectric polymer transducer for the recording of pressure transients developed over the interface between two bodies as a result of impact are described. A bilaminate design was selected which uses electrically poled sheets of 25 micrometer polyvinylidene fluoride as the active material. The intended primary response of the transducer is to compression in the thickness direction, produced by either hydrostatic or normal pressure. The transducer was also found to respond to extension in the membrane direction. Static and dynamic methods for characterizing transducer output are described. In particular, in order to simulate field conditions in which the transducer may bend or stretch, or both, during impacts, a drop-test procedure with curved impactors has been devised and a theoretical analysis has been developed to yield the interface pressure.

by Aime S. DeReggi  
National Bureau of Standards, Dept. of Commerce,  
Washington, D.C. 20234  
Contract DOT-HS-4-00835 IA  
1975 ; 39p 8refs  
Rept. for Dec 1973-Dec 1974.  
Availability: NTIS

HS-801 782

**SPRAY PROTECTOR TESTING ON TRUCKS. FINAL REPORT**

The National Highway Traffic Safety Administration has proposed a Motor Vehicle Safety Standard to establish requirements for spray protectors to reduce the obscuring of view of following drivers by spray and debris thrown up by vehicle wheels. A series of tests was conducted to obtain data on the amount of spray contributed by each wheel from a truck tractor and semi-trailer combination vehicle and by a truck transport when tested under variable conditions of vehicle loading, tire wear, road conditions, and road moisture. Experimental testing was conducted on both rough and smooth road surfaces using two trucks with new tires and worn tires, loaded and unloaded, and under road moisture conditions of heavy water and light water. Tests were made obtaining slow motion movie pictures, still pictures, and spray intensity data. Techniques using a densitometer and a photometer were developed to determine the amount of spray produced at individual wheels and for the total vehicle. From the densitometer analysis of photographs the amount of spray contributed by the rear wheels of a specific truck transport can be stated

to be 2.53 times greater than the spray contributed by the front wheels. For a given truck tractor and semi-trailer combination, the amount of spray contributed by the trailer wheels was found to be 2.7 times greater than the spray contributed by the front wheels and the spray contributed by the center wheels is 1.65 times greater than the front wheel spray. The degree of tire wear was found to be a negligible factor in the total amount of spray produced in heavy water conditions. The type of road surface is not a significant factor in the total amount of spray produced. The degree of vehicle loading was not consistently significant in its effect on spray generation. It is concluded that densitometer measurement of photo negatives of spray patterns generated behind each wheel appears to be a sensitive and effective technique for determination of comparative spray propagation by individual wheels, if standardized photographic control procedures are used. A photometric spraymeter for quantitative comparison of the amount of spray contributed by each individual wheel has the ability to measure spray intensity. The use of a water collector device does not appear to be a feasible technique for even qualitative comparisons of the amount of spray produced by individual wheels or the vehicle due to wide variability resulting from the location of the collector in the spray patterns.

by Thomas E. Ritter  
Southwest Res. Inst., 8500 Culebra Rd., San Antonio, Tex. 78284  
Contract DOT-HS-024-2-469  
Rept. No. AR-848 ; 1972 ; 52p  
Availability: Reference copy only

HS-801 783

**TRUCK SPLASH AND SPRAY TESTS AT MADRAS, OREGON. FINAL REPORT**

A series of tests was conducted at Madras, Oregon, to evaluate several devices designed to suppress the spray generated by trucks travelling at speeds greater than 50 mph on wet roads. The test trucks used were two identical truck tractor and semi-trailer combinations. The four spray-suppressor devices tested were: the Roberts fender, which converts the fine water spray from the wheel into heavier water droplets which are deposited on the road away from the tire; the Reddaway fender, which uses an astroturf material to collect the fine spray, which coalesces and runs off the fender and back on the road in larger droplets; the Koneta fender, which is made of rubber and shrouds the upper portion of the tires and directs the spray toward the center of the vehicle; and the PABS fender, an aluminum device which collects the fine spray and directs it through tubes toward center of the vehicle for discharge onto the road. Photographic coverage of the test program included movie film of the test course, vehicles, and spray-suppressor devices, as well as of the progress of the test. A photometer recorded the spray density generated by the test truck on a strip-chart recorder and a densitometer was used to analyze photographic negatives taken at the test site. The spray-measurement techniques used were found to provide effective and efficient means with which to acquire quantitative spray density data for the evaluation of spray-suppressor devices. A good correlation between the densitometer and photometric techniques used to measure relative spray density was obtained. The test course and conditions used in these experiments were not considered ideal for conducting these types of tests. None of the four devices examined provided a substantial reduction in spray. Spray reduction ranged from between 15 and 20% for the PABS fender to about 2% with

the Koneta fender. Numerous photographs of the devices are included.

by Thomas E. Ritter  
Southwest Res. Inst., 8500 Culebra Rd., San Antonio, Tex.  
78284  
Contract DOT-HS-5-01040  
Rept. No. AR-955 ; 1974 ; 30p  
Report for 15 Jul-15 Oct, 1974.  
Availability: Reference copy only

HS-801 785

### **HIGHWAY SAFETY PROGRAM MANUAL. VOL. 16. DEBRIS HAZARD CONTROL AND CLEANUP**

The purpose of the Debris Hazard Control and Cleanup Program of the National Highway Traffic Safety Administration is to provide for the prompt removal of damaged or disabled vehicles from the crash site and for the cleanup of any dangerous spillages resulting from crashes or other mechanical breakdowns of vehicles on public thoroughfares in order to lessen the probability that the debris will create additional hazards and dangers and to relieve congestion and expedite the resumption of normal traffic flow. Planning steps used by states and local governments in developing an effective debris hazard control and cleanup capability should include: initial planning study; inventory of existing resources and capabilities; comparison of requirements with resources and capabilities; development of a plan; implementation of the plan; and evaluation of the plan. Communication and training needs of the program are outlined. Operational phases which must be planned for include: detection; notification of the responsible agency; response; restoration procedures; restoration of traffic movement; and data collection. It is suggested that comprehensive analyses be performed periodically on the effectiveness of program procedures as applied to a selected sample of instances where debris hazards occurred. The program is to be periodically evaluated by the state, with the National Highway Traffic Safety Administration receiving an evaluation summary.

National Hwy. Traffic Safety Administration, Washington,  
D.C.  
1975 ; 60p Grefs  
See also HS-820 050.  
Availability: GPO \$1.25, stock no. 050-003-00209

HS-801 790

### **SAFETY BELT INTERLOCK SYSTEM USAGE SURVEY. MONTHLY PROGRESS REPORT NO. 9, SEPTEMBER 1975**

A safety belt interlock system usage survey utilizing traffic records (and questionnaires) for selected drivers in 19 cities in 16 states is presented. Current observation data showing results (based on observations conducted from February 1974 to September 1975) by city, sex of driver, manufacturer, and seat type are appended. Accomplishments, problems and funds committed during the present reporting period, and planned accomplishments for coming reporting periods are discussed.

by Albert Westefeld  
Opinion Res. Corp., North Harrison St., Princeton, N.J. 08540  
Contract DOT-HS-5-01039  
Rept. No. PR-9 ; 1975 ; 8p  
Availability: Reference copy only

HS-801 791

### **SAFETY BELT INTERLOCK SYSTEM USAGE SURVEY. MONTHLY PROGRESS REPORT NO. 10, OCTOBER 1975**

A safety belt interlock system usage survey utilizing traffic records (and questionnaires) for selected drivers in 19 cities in 16 states is presented. Current observation data showing results (based on observations conducted from February 1974 to September 1975) by city, sex of driver, manufacturer, and seat type are appended. Accomplishments, problems, and funds committed during the present reporting period, and planned accomplishments for coming reporting periods are discussed.

by Albert Westefeld  
Opinion Res. Corp., North Harrison St., Princeton, N.J. 08540  
Contract DOT-HS-5-01039  
Rept. No. PR-10 ; 1975 ; 10p  
Availability: Reference copy only

HS-801 793

### **EFFECTIVENESS OF VARIOUS SAFETY BELT WARNING SYSTEMS. MONTHLY PROGRESS REPORTS NO. 1-6, JUNE-NOVEMBER 1975**

A study of the effectiveness of seat belt warning systems installed in the cars of three rental agencies if Phoenix, Arizona is presented. Accomplishments, problems, and funds committed during each of six reporting periods, and planned accomplishments for each coming reporting period are discussed. As of October 15, 1975, 736 cars had been modified with some warning system. Results based on 4,241 observations of seat belt wearing rates are reported for the following warning system modifications: no warning system (control); 7-8 second non-sequential buzzer; 4-5 second non-sequential buzzer; 7-8 second sequential buzzer-continuous light; 7-8 second intermittent buzzer-continuous flashing light; and a 7-8 second sequential logic--light and buzzer off in 7-8 seconds.

by Albert Westefeld  
Opinion Res. Corp., North Harrison St., Princeton, N.J. 08540  
Contract DOT-HS-5-01154  
Rept. No. PR-1; PR-2; PR-3; PR-4; PR-5 ; 1975 ; 20p  
Availability: Reference copy only

HS-801 807

### **PERFORMANCE CERTIFICATION REPORT FOR 50TH PERCENTILE MALE ANTHROPOMORPHIC TEST DUMMY [ALDERSON]. TESTS PERFORMED TO REQUIREMENTS OF PART 572. FINAL REPORT**

The following performance certification tests were performed on two 50th percentile male anthropomorphic test dummies, manufactured by the Alderson Research Laboratories, to satisfy the requirements of Part 572: head drop test, neck pendulum test, chest impact test, lumbar flexion test, knee impact test, and abdomen compression test. The dummies demonstrated certain areas of non-compliance: both dummies failed to meet low speed deflection requirements in thorax testing; and in lumbar testing, one dummy did not consistently meet high flexion forces, or return angle requirements. Calibration data are summarized, and descriptions of vehicle tests from the dummy usage log are included.

June 31,1976

HS-801 809

by C. Bonelli  
Ultrasystems, Inc., 1850 West Pinnacle Peak Rd., Phoenix,  
Ariz. 85027  
Contract DOT-HS-046-3-784  
Rept. No. 572-DYS-75-001-Alderson; 3887-75-183 ; 1976 ; 23p  
Cover title: 50th Percentile Male Anthropometric Test Dummy  
Performance Certification. Regulation Part 572. Rept. for 1  
Nov 1974-1 Dec 1975.  
Availability: Reference copy only

HS-801 808

**PERFORMANCE CERTIFICATION REPORT FOR  
50TH PERCENTILE MALE ANTHROPOMORPHIC  
TEST DUMMY [HUMANOID]. TESTS PERFORMED  
TO REQUIREMENTS OF PART 572. FINAL REPORT**

The following performance certification tests were performed on two 50th percentile male anthropometric test dummies, manufactured by Humanoid Systems, to satisfy the requirements of Part 572: head drop test, neck pendulum test, chest impact test, knee impact test, lumbar flexion test, and abdomen compression test. The dummies demonstrated certain areas of non-compliance: they did not repeatably meet either the deflection or force requirements for thorax testing; and in abdomen testing, the dummies did not consistently meet low deflection force requirements. Calibration data are summarized, and descriptions of vehicle tests from the dummy usage log are included.

by C. Bonelli  
Ultrasystems, Inc., 1850 West Pinnacle Peak Rd., Phoenix,  
Ariz. 85027  
Contract DOT-HS-046-3-784  
Rept. No. 572-DYS-75-002-Humanoid; 3887-75-184 ; 1976 ; 23p

Cover title: 50th Percentile Male Anthropomorphic Test Dummy Performance Certification. Regulation Part 572. Rept. covers 1 Nov 1974-1 Dec 1975.  
Availability: Reference copy only

HS-801 809

**PERFORMANCE CERTIFICATION REPORT FOR  
50TH PERCENTILE MALE ANTHROPOMORPHIC  
TEST DUMMY [SIERRA]. TESTS PERFORMED TO  
REQUIREMENTS OF PART 572. FINAL REPORT**

The following performance certification tests were performed on two 50th percentile male anthropomorphic test dummies to satisfy the requirements of Part 572: head drop test, lumbar flexion test, neck pendulum test, chest impact test, knee impact test, and abdomen compression test. The dummies were manufactured by the Sierra Engineering Company. They demonstrated certain areas of non-compliance: the dummies did not repeatably meet either the deflection or force requirements for thorax testing; and in abdomen testing, the dummies did not consistently meet low deflection force requirements. Calibration data are summarized, and descriptions of vehicle tests from the dummy usage log are included.

by C. Bonelli  
Ultrasystems, Inc., 1850 West Pinnacle Peak Rd., Phoenix,  
Ariz. 85027  
Contract DOT-HS-046-3-784  
Rept. No. 572-DYS-75-003-SIERRA; 3887-75-185 ; 1976 ; 19p  
Cover title: 50th Percentile Male Anthropomorphic Test Dummy Performance Certification. Regulation Part 572. Rept. covers 1 Nov 1974-1 Dec 1975.  
Availability: Reference copy only



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June 31,1976

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THE VOICE OF THE TRANSPORTATION CONSUMER. A REPORT TO THE SECRETARY OF TRANSPORTATION ON NATIONWIDE CONSUMER PUBLIC HEARINGS CONDUCTED BY THE OFFICE OF CONSUMER AFFAIRS. EXECUTIVE SUMMARY

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**CONFERENCE**

BIOMECHANICS OF SERIOUS TRAUMA. PROCEEDINGS OF THE 2ND INTERNATIONAL CONFERENCE, BIRMINGHAM, SEPTEMBER 9, 10, 11, 1975

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**CONGRESS**

SPECIAL REPORT TO THE U.S. CONGRESS ON ALCOHOL AND HEALTH (2ND) FROM THE SECRETARY OF H.E.W. JUNE 1974. CHAP. 6, ALCOHOL AND HIGHWAY SAFETY

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ANNUAL REPORT AND RESOLUTIONS OF THE COUNCIL OF MINISTERS (21ST). EXTRACT COPY

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AN ATTEMPT TO DEFINE THE TOLERANCE OF THE  
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DEFINITION DE LA TOLERANCE DE LA TETE DES  
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STATISTICAL AND CLINICAL STUDY DEFINING  
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STATISTIQUE ET CLINIQUE PRECISANT LA  
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**DEFINITION**

AN ATTEMPT TO DEFINE THE TOLERANCE OF THE  
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DEFINITION DE LA TOLERANCE DE LA TETE DES  
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**DIEGO**

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AIR WEDGE DISC BRAKES FOR HEAVY TRUCK  
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**DISPOSITIFS**

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DIVE IMPACT TESTS AND MEDICAL ASPECTS OF A  
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**DIVER**

DIVE IMPACT TESTS AND MEDICAL ASPECTS OF A  
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June 31,1976

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Center, Kendall Square, Cambridge, Mass. 02142

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<b>SAE-751164</b>	HS-018 126	<b>TCR-0283</b>	HS-801 772
<b>SAE-751165</b>	HS-018 127	<b>TCR-0283-FR</b>	HS-801 771
<b>SAE-751166</b>	HS-018 128	<b>TOR-059-75</b>	HS-017 996
<b>SAE-751167</b>	HS-018 129	<b>TSC-OST-74-42.I</b>	HS-017 986
<b>SAE-751168</b>	HS-018 130	<b>UM-HSRI-HF-74-27</b>	HS-018 008
<b>SAE-751169</b>	HS-018 131	<b>UM-HSRI-SA-75-12</b>	HS-018 006
<b>SAE-751170</b>	HS-018 132	<b>VRI-7.2</b>	HS-018 035
<b>SAE-751171</b>	HS-018 133	<b>3887-75-183</b>	HS-801 807
<b>SAE-751172</b>	HS-018 134	<b>3887-75-184</b>	HS-801 808
<b>SAE-751173</b>	HS-018 135	<b>3887-75-185</b>	HS-801 809
<b>SAE-751176</b>	HS-018 137	<b>572-DYS-75-001-Alderson</b>	HS-801 807
<b>SAE-759023</b>	HS-017 988	<b>572-DYS-75-002-Humanoid</b>	HS-801 808
<b>SAE-759024</b>	HS-017 989	<b>572-DYS-75-003-SIERRA</b>	HS-801 809



# VALIDITY TEST OF NEW YORK STATE INJURY CODING SCHEME (NYSICS)

by

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## I. BACKGROUND

A. Section 1. Over the past two years the Traffic Records Project of New York State and participants from other State agencies have been actively involved in the design and implementation of an injury coding method which would provide a more effective means of describing automotive accident injuries than the previously existent K-A-B-C injury scale contained in the New York State MV-104A Police Accident Report form. It was the consensus of this group that the simplified coding scheme to be developed should be standardized, comprehensive, and universally adaptable.

It was realized that the broad spectrum of injuries that can occur as a result of an automotive accident could not be determined and classified in medically specific terms by police, since police do not normally have formal training in injury determination and classification. It was felt, however, that specific areas of body injury, the most severe injury to that part of the body, and the victim's physical and emotional status could be accurately observed by the accident investigator and recorded by use of a coding scheme.

B. Section II of this paper, *Description of Injury Code Systems*, describes the injury code designed by the Traffic Records Project of New York State. Section III, *Test of 1973*, reviews the initial test of that injury code (NYSICS) by Troop F of the New York State Police and presents the results of that test.

Section IV, *Test of 1974*, describes the follow-up test which was conducted and involved police agencies of all levels Statewide to insure the universality and validity of the New York State Injury Coding Scheme (NYSICS).

## II. DESCRIPTION OF INJURY CODE SYSTEMS

### A. National Standard System

The injury codes cited in the *Manual on Classification of Motor Vehicle Traffic Accidents*<sup>1</sup> are divided into 5 categories. They are known as the National Standard Values, and are:

1. Fatal Injury
2. Incapacitating Injury
3. Nonincapacitating Evident Injury
4. Possible Injury
5. No Injury

These National Standard Values had been compressed by New York State into K, A, B, or C designations. The description of the K, A, B, and C values used in New York State prior to 1974 are as follows:

K = Fatal

A = Incapacitating injury which includes:

Severe lacerations, broken or distorted limbs, skull fracture, crushed chest, internal injuries, unconscious when taken from scene; unable to leave scene without assistance.

B = Non-incapacitating evident injury which includes:

Lump on head, abrasions, minor lacerations.

C = Possible injury which includes:

Momentary unconsciousness. Claim of injuries (not evident); limping, complaint of pain, nausea, hysteria.

The findings in *Injury Reporting Reliability*<sup>2</sup> of the New York State Traffic Records Project indicated that direct coding into K-A-B-C did not appear to give a reliable measure of injury severity.

<sup>1</sup>National Safety Council, Chicago. *Manual on Classification of Motor Vehicle Traffic Accidents*, 2nd ed., 1970. ANSI D16-1-1970.

<sup>2</sup>Kenneth Carpenter. *Injury Reporting Reliability*. New York

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American Hospital Association representative with

The new injury code described in this report consists of three parts. They are the *Location of the Most Severe Physical Complaint*; the *Type of Physical Complaint*; and the *Victim's Status*.

The following information reflects the three categories and the elements within those categories which were used in the initial field test.

1. The categories for the Location of the Most Severe Physical Complaint are:

- |                        |                             |
|------------------------|-----------------------------|
| A. Head                | H. Elbow, lower arm, hand   |
| B. Face                |                             |
| C. Eye                 | I. Hip, upper leg           |
| D. Neck                | J. Knee, lower leg, foot    |
| E. Chest               |                             |
| F. Back                | K. Abdomen                  |
| G. Shoulder, upper arm | L. Victim (over-all status) |

2. The Types of Physical Complaint and their definitions were as follows:

- (1) Amputation—Severed parts.
- (2) Concussion—Dazed condition as a result of blow to head.
- (3) Internal—No visible injury but signs of anxiety, internal pain, thirst.
- (4) Minor Bleeding—Slight discharge of blood.
- (5) Severe Bleeding—Steady flow of blood that is not controlled.
- (6) Minor Burn—Reddening of skin.
- (7) Moderate Burn—Reddening, blistering of skin over large area.
- (8) Severe Burn—Reddening, blistering or charring of the skin over large portion of the body.
- (9) Fracture—Dislocation—Evidence of displacement of bones.
- (10) Bruise—Discoloration.
- (11) Abrasion—Top layer of skin is scraped.
- (12) Complaint of pain.
- (13) None—No visible injuries but victim is other than normal.

3. Victim's Status was defined as follows:

- (1) Apparent Death.
- (2) Unconscious—Victim unaware of his surroundings, does not respond to stimuli (verbal or physical).
- (3) Semi-conscious—Victim not fully aware of his surroundings.
- (4) Incoherent—Lacking orderly continuity of thought.
- (5) Shock—Depressed condition of all body functions, resulting from serious injury or incident.

Others have worked with injury codes consisting of several fields. The code developed for multi-disciplinary accident investigation by the Highway Safety Research Institute has five fields.<sup>3</sup> This is more detailed and more medically exact than seems practical to request of a policeman. One of the objectives of the code described in this report is to minimize the writing out of the injury description and to eliminate the evaluation by the policeman as to the severity of injury. Additionally, this scheme now makes it possible to gather more detailed information than was previously recorded. The numeric code format also gives capability for easy computer entry and retrieval. The New York State Injury Coding Scheme, describing the Location of the Most Severe Physical Complaint, Type of Physical Complaint, and the Victim's Status, is produced by the policeman from what he sees and hears from the injured at the site of a collision. Nevertheless, in spite of the differences in methods of coding between the two sets of codes, there is much similarity between the entries for location of injury and for type of physical complaint between the multi-disciplinary in-depth injury code and the recommended New York State Traffic Records Injury Code.

### III. TEST OF 1973

A. The 1973 test was conducted in order to determine the validity of NYSICS.

A test of the new accident injury codes was carried out jointly by Troop F of the New York State Police in Middletown, New York and by 17 hospitals in the area, under the coordination of the New York State Department of Health. From February 26, 1973 through March 18, 1973, the State Police augmented their regular reporting with a special form (Appendix A) incorporating the New York State Injury Coding Scheme and information about hospitalization of the injured.

The emergency rooms in the hospitals reported the diagnosis of injury and whether the victim remained in the hospital. Out of 152 cases, there were 31 people injured who did not go to the hospital; 60 who were given outpatient treatment; 21 who were hospitalized; and one fatality. There were 39 events with no matching forms.

<sup>3</sup> Joseph C. Marsh IV. *Existing Traffic Accident Injury Causation Data Recording Methods and the Proposal of an Occupant Injury Classification Scheme*. Highway Safety Research Institute, Ann Arbor, Michigan, 1972.

and David A. Stephens, of the New York State Department of Health, Emergency Medical Services, and the author, then with the Traffic Records Project. The areas studied and commented on were the following:

1. Is the new coding system easier to handle than a narrative description of the injury? There was consensus between Emergency Medical Services personnel and the State Police. It is faster and more efficient to code three numbers than to try to describe injuries in layman's terms.

Since the terms used are quite similar to those used by ambulance personnel in the State, there is little chance of a description being misunderstood among users of this data. It was also noted that the description of the anatomy and types of injury sustained were general enough to allow semi-skilled medical personnel to render an opinion and still be precise enough to agree with the opinion of emergency room personnel.

2. Is this code workable?

Of the 152 police reports returned, only eight were multiple-coded in column one (Location of Most Severe Physical Complaint) and/or two (Type of Physical Complaint). Of these, five could be attributed to a single policeman. It therefore seemed that with a reasonable amount of training (the police in the test were given less than one hour), the police can select the single most severe element of injury.

There were 82 police reports for which there were matching emergency room reports. The Emergency Medical Service people stated that 80 of the 82 were satisfactorily similar. Tables 1, 2 and 3 summarize the results of the 82 cases and of the 31 cases in which the injured did not go to the hospital. Two improperly coded reports represent injured who went to the hospital and then home, as was the driver charged with DWI who went to jail. The fatality is included with those who were hospitalized. The results show much similarity in the distribution of the Location of the Most Severe Physical Complaint and Type of Physical Complaint between those who did not go to the hospital and those who were treated in the emergency room and discharged. Those who were hospitalized had different distributions on all three tables.

The difficulty in distinguishing the various kinds of shock from true surgical shock, which is a

Location of Physical Complaint	Hospital To		
	No Hospital	Home	Hospital
A. Head -----	8	15 <sup>+</sup>	5
B. Face -----	7	11	5
C. Eye -----		2	
D. Neck -----	2	5	1
E. Chest -----		4	2
F. Back -----	1	1	4
G. Shoulder, Upper Arm -----	1	6	
H. Elbow, Lower Arm, Hand -----	4	4	1
I. Hip, Upper Leg -----	1	1	1
J. Knee, Lower Leg, Foot -----	6	11 <sup>+</sup>	1
K. Abdomen -----			1
L. Victim (over all status) -----	1		1
	31	60	22

\* The location of physical complaint reported by the police differed from that reported on the Emergency Room Face Sheet.

TABLE 2  
Results of Field Test  
Type of Physical Complaint

Type of Physical Complaint	Hospital To		
	No Hospital	Home	Hospital
1. Amputation -----			
2. Concussion -----		1	1
3. Internal -----			3
4. Minor Bleeding -----	7	23 <sup>+</sup>	2
5. Severe Bleeding -----			6
6. Minor Burn -----			
7. Moderate Burn -----			
8. Severe Burn -----			
9. Fracture-Dislocation -----	1	1	5
10. Contusion-Bruise -----	5	10	2
11. Abrasion -----	2	5	
12. Complaint of Pain -----	16	20 <sup>+</sup>	3
13. None -----			
	31	60	22

\* The location of physical complaint reported by the police differed from that reported on the Emergency Room Face Sheet.

TABLE 3  
Results of Field Test  
Victim's Status

Victim's Status	Hospital To		
	No Hospital	Home	Hospital
Apparent Death -----			1
Unconscious -----			1
Semi-conscious -----			5
Incoherent -----			
Shock -----	1	4	2
Normal -----	30	55 <sup>+</sup>	13
Blank -----		1	
	31	60	22

\* The victim's status reported by the police differed from that reported on the Emergency Room Face Sheet.

patho-physiological life-threatening patient situation, is recognized.

There is no easy solution to the problem of diagnosing shock in a motor vehicle accident and every effort should be made to train personnel in recognizing the different types described in this report. The definition used in the test was for traumatic shock, a condition requiring immediate medical attention. The results of the test indicated that "shock" was also used for psychogenic shock and for hysteria. Psychogenic shock is associated with a fainting condition, and is not as serious as traumatic shock. Hysteria is a temporary condition requiring only psychological first aid. The average policeman will probably more readily recognize hysteria than either traumatic or psychogenic shock. One can only suspect which kind of shock is sustained by analyzing the rest of the injury description. Since any of the three types of shock could be expected after an automotive accident, it was decided to change the definition of "shock" in the Victim's Status column to include them all.

### 3. Is it compatible with the *Manual on Classification of Motor Vehicle Accidents*?

The job of translating this injury coding system into the National Standard Values published in the *Manual* would be handled as shown in Table 4.

There are three categories which lead to an "A" injury. (It is felt that the term incapacitating should mean "Hospitalized or unable to perform one's normal vocational functions.") In all of these, the shock is traumatic shock. The two categories which translate to a "B" injury are psychogenic shock, and the entry under "C" is hysteric shock.

All elements of this study are compatible with the National Standard in that they can be translated back into K-A-B-C type injuries to conform with the National Standard definitions of extent of injury in motor vehicle accidents.

The Traffic Records Project feels there is a need for a more precise code than the current National Standard levels. The New York State Injury Coding Scheme is similar to, but more compact than, the in-depth studies which were done by such groups as the Highway Safety Research Institute. The initial field test of this code has yielded accurate results with minimal police training. The coding system also clearly differentiates among the most severe types of injuries and can contrast them with lesser

Also, based on this study, and after consulting with the Department of Health, several areas of The New York State Injury Coding Scheme were altered to reflect priorities in coding and accuracy in terminology (see Table 5).

TABLE 4  
Translation of New York State  
Injury Coding Scheme to K-A-B-C

<i>New York State K-A-B-C Classification</i>	<i>Location Of Injury</i>	<i>Type of Complaint</i>	<i>Victim's Status</i>
K	Any Entry	Any Entry	Apparent Death
	Any Entry	Any Entry	Unconscious Semi-conscious Incoherent
A	Any Entry	Amputation Concussion Internal Severe Bleeding Severe Burn Fracture- Dislocation	Shock Normal
	Eye	Minor Bleeding Minor Burn Complaint of Pain	Shock Normal
B	All But Eye	Minor Bleeding Minor Burn	Shock Normal
	Any Entry	Contusions- Bruise Abrasion	Shock Normal
C	All But Eye	Complaint of Pain	Shock Normal

TABLE 5  
Explanation of New York State Injury Coding Scheme  
and Abbreviated Injury Scale Injury Codes  
for Translation Purposes

<i>Location of Most Severe Physical Complaint</i>	<i>Type of Physical Complaint</i>	<i>Victim's Physical and Emotional Status</i>
Column 1	Column 2	Column 3
1. Head	1. Amputation	1. Apparent Death
2. Face	2. Concussion	2. Unconscious
3. Eye	3. Internal	3. Semiconscious
4. Neck	4. Minor Bleeding	4. Incoherent
5. Chest	5. Severe Bleeding	5. Shock
6. Back	6. Minor Burn	6. Conscious
7. Shoulder, Upper Arm	7. Moderate Burn	
8. Elbow, Lower arm, hand	8. Severe Burn	
9. Abdomen, Pelvis	9. Fracture-dislocation	
10. Hip, upper leg	10. Contusion-Bruise	
11. Knee, lower leg, foot	11. Abrasion	
12. Entire Body	12. Complaint of Pain	

"LOCATION OF PHYSICAL COMPLAINT" was changed to "LOCATION OF MOST SEVERE PHYSICAL COMPLAINT" because it had been asked of the police officer to note only the single most severe location of injury.

Additionally, under "LOCATION OF MOST SEVERE PHYSICAL COMPLAINT," the codes were changed from Alpha to Numeric in order to provide uniformity for computer entry. Also, the order of elements in this category was changed so that the police officer could follow the anatomic breakdown more easily: (9) "Abdomen, Pelvis" was added and placed before (10) "Hip, Upper Leg," (11) "Knee, Lower Leg, Foot."

Under "TYPE OF PHYSICAL COMPLAINT," (13) "None" was changed to read "None Visible." It was felt that this description would give the police officer more confidence in reporting some types of internal injuries.

"VICTIM'S STATUS" was changed to "VICTIM'S PHYSICAL AND EMOTIONAL STATUS" because it was felt that the emotional factor concerning an injured person was important in gathering a clearer picture of the injury. Also, under "VICTIM'S PHYSICAL AND EMOTIONAL STATUS," (6) "Normal" was changed to "Conscious" because the term "Normal" is relative to the condition and does not necessarily mean conscious and aware of surroundings.

#### IV. TEST OF 1974

##### A. Need for retest.

It was determined that a bias might have existed in the 1973 test since it had been conducted for only a short period of time under close supervision and the test participants were aware that their observations were being evaluated by Emergency Room physicians.

Since the new injury coding scheme had been incorporated into the revised MV-104A Police Accident Report form on January 1, 1974, an unbiased test was needed to insure the validity of the New York State Injury Coding Scheme (NYSICS). It was further determined that it was necessary for the injury code to have universal appeal throughout the various levels of police disciplines, since the first test had been completed only by New York State Police. Additionally, it was considered desirable to test the code geographically Statewide, to determine police personnel acceptance of the form and accuracy of completion in areas of the State with different population characteristics (small

##### B. Methodology.

The second test, which ran from May 15, 1974 through June 30, 1974, sampled selected areas of the State of New York with the exception of New York City. New York City was not selected because the mass of information would be too unwieldy to handle.

Participating in the validity test were 24 hospitals located in five geographic regions of the State (Long Island, Downstate/White Plains, Northeastern, Central and Western). The hospitals chosen were purposely of different sizes serving different types of communities (urban and rural). The one common denominator was the hospital's ability to treat victims of traffic accidents. The capabilities of these hospitals were obtained from Emergency Medical Services Bureau personnel in each respective Health Department region.

In order to implement the test, Traffic Records once again requested and received the complete cooperation of the New York State Department of Health and its Bureau of Emergency Medical Services. The good rapport with health facilities throughout the State enjoyed by these organizations made the proposal for a test more acceptable to the hospitals selected.

Initially, the proposed test and its rationale were presented to Frank T. Cicero, M.D., Assistant Commissioner for Health Facilities Financing and Development, and to Donald C. Walker, M.D., Assistant Commissioner for Health Manpower. Their comments, criticisms and advice on the approach to be used were of immeasurable value.

An Emergency Medical Services Bureau representative in each of the five regions was selected, and the author contacted either the hospital administrator or the Emergency Room physician to explain the purpose and need for the validity test, to gain hospital permission to conduct the test and to explain the proper use of the forms involved. It was strongly emphasized that these reports would be filled out for only those admitted as a result of a motor vehicle accident. Additionally, the hospital personnel contacted were informed that the police in their regions had no knowledge that the test was being conducted. As previously noted, this was done in order to prevent the possible bias that might have existed in the test conducted with the State Police in 1973.

With hospital participation assured, the test was ready to begin, and special Emergency Room Form Sheets modified for these test purposes

records. During the week beginning May 10, 1974, the completed special Emergency Room Face Sheets began to be received by the Traffic Records Project. These face sheets, in turn, were matched with the respective MV-104A Police Accident Report form which contained the police officer's record of injury information by using the new injury coding scheme.

The matching process was simplified by including the driver's name on the special test Emergency Room Face Sheet, as well as the name of the victim. The process made access into the Department of Motor Vehicles computerized file possible, since information relative to a motor vehicle accident is entered on the driver's record.

It had been strongly stressed in police accident reporting instruction seminars that the police should record only the single most severe injury suffered by the accident victim and, therefore, this was the criteria used when evaluating special test Emergency Room diagnosis. If the police officer had recorded the single most severe injury and the hospital concurred, then it was considered a "match." If, in fact, the police officer recorded a lesser injury and the hospital had diagnosed a more severe one, then the case was considered a "no match"; and, in the case where two or more severe injuries were sustained, only the one cited as most severe on the Emergency Room Face Sheet was considered for matching purposes.

During the initial evaluation period, a number of these Emergency Room records, along with the police reports, were reviewed by Dr. John D. States of the University of Rochester School of Medicine, in order to maintain objectivity about our coding scheme. His evaluation was in agreement, in every instance, with that of Traffic Records and Emergency Medical Services personnel.

#### C. Results.

By the end of the test period, a total of 1,091 special test Emergency Room Face Sheets were returned to Traffic Records for evaluation. Of these 1,091, 667 could be linked with a police report that had been filled out during the investigation of the accident.

Of these 667, 44 of the special test Emergency Room Face Sheets had no diagnosis, although the corresponding police reports contained injury information. In addition, 27 police accident reports did not contain injury information, although an Emergency Room Face Sheet had been completed. Since diagnostic information

comparative analyses with respect to the validity of NYSICS, and since it was impossible to determine the exact reasons for reports being devoid of that information, these 71 records were not considered for test evaluation purposes. Eliminating those cases where there was no diagnosis (either police or special test Emergency Room Face Sheet) left 596 usable records from which corresponding coding by first responders (police) and medical personnel (doctors and nurses) could be compared.

After comparing these documents, it was determined that in 500 cases or 83.9 percent of the 596 usable matched cases investigated, the police opinion concurred with that of the hospital.

In reviewing the accident cases where hospital and police injury diagnosis differed, Traffic Records determined that the greatest difference of diagnostic opinion occurred in instances where burns and internal injuries were involved. However, this is to be expected since the type of burn and the body area it covers make it difficult for the police officer with limited medical knowledge to be more exact. The same is true of internal injuries where symptoms are often slow to develop and the officer's medical knowledge and diagnostic ability are minimal. It is anticipated that more accurate reporting in this area will result after continued use of the codes by police personnel.

The following table (Table 6) of injuries presents the distribution of matching.

#### D. Test Evaluation.

- The evaluation of injuries took into consideration the individual in the Emergency Room who had made the preliminary diagnosis. Of those where doctors made the diagnosis, 86.6 percent had valid matches. In 80.7 percent of the cases where the diagnosis was made by a Registered Nurse there was a valid match. This difference was not found to be statistically significant.
- Another important part of the testing was to determine whether or not all types of police agencies could handle this coding scheme, since the original pilot test was conducted by State Police personnel only. When the results were tallied, it was found that municipal or local police agencies on a Statewide basis were not significantly different in their injury observations than were the State Police. The State Police had an accuracy rate of 87.5 percent, while all other police agencies averaged 83.9 percent accuracy in coding.

Type of Physical Complaint								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
		Usable			Not Usable			
Type of Physical Complaint	Total	Matching Police Report	Recorded But Bad Match	Matched OK	No Matching Police Report	No Diagnosis On ER Sheet	Not Stated On Police Report	
01 Amputation -----	1	1	0	1	0	0	0	
02 Concussion -----	26	24	3	21	0	0	2	
03 Internal -----	15	14	5	9	0	0	1	
04 Minor Bleeding -----	138	138	16	117	2	1	2	
05 Severe Bleeding -----	41	37	5	32	1	1	2	
06 Minor Burn -----	2	2	0	2	0	0	0	
07 Moderate Burn -----	0	0	0	0	0	0	0	
08 Severe Burn -----	2	2	1	1	0	0	0	
09 Fracture-dislocation -----	41	38	7	31	2	0	1	
10 Contusion-Bruise -----	56	52	5	47	1	1	2	
11 Abrasion -----	25	22	4	18	0	1	2	
12 Complaint of Pain -----	208	195	30	165	6	2	5	
13 None Visible -----	45	44	15	29	0	1	0	
Not Stated -----	491	32	5	27	412	37	10	
Total -----	1,091	596	96	500	424	44	27	

TABLE 7

Comparison of Matched Reports With Diagnosis  
by First Responders (Police) and  
Emergency Room Staff

Emergency Room Staff	Number of Matched Cases		Number With Non-Valid Match	Number With Same Diagnosis	Percent With Valid Match
	With Diagnosis	Percent of Total			
Doctors -----	262	44.0	35	227	86.6
Registered Nurses -----	239	40.0	46	193	80.7
Others -----	17	2.9	1	16	94.1
Not Stated ---	78	13.1	14	64	82.1
Total -----	596	100.0	96	500	83.9

Since only 27 of the 667 records had no diagnosis recorded on the police report, the test showed only 4 percent of matching police reports were incomplete as to the coding of injuries.

- This test also provided us with information concerning the mode of transportation to the hospital. It was found that the vehicle types and agencies are representative of the various types existing in the State. They range from volunteer, commercial, hospital based and coroner's vehicle, to those ambulance agencies run by municipalities.

Although the results of this "in the field" reliability test were extremely encouraging, it was felt that no new injury scale could be considered valid until it had been compared with a scale that has been accepted universally. Accordingly, we began the translation of this injury coding scheme into the Abbreviated Injury Scale (AIS) which was co-authored by Dr. States.<sup>4</sup> (See Table 8.) Once the work on the translation was completed (giving an AIS value to each possible combination), it was sent to Dr. States for his comments and criticisms.

TABLE 8

Abbreviated Injury Scale

1. Minor Injury
2. Moderate Injury
3. Severe Injury (not life-threatening)
4. Severe Injury (life-threatening, survival probable)
5. Critical Injury (survival uncertain)
6. Fatal Injury (within 24 hours)—Fatal lesions of single region of body, plus injuries of other body regions of severity Code 3 or less
7. Fatal Injury (within 24 hours)—Fatal lesions of single region of body, plus regions of severity Code 4 or 5
8. Fatal—2 fatal lesions in regions of body
9. Fatal—3 or more fatal injuries

<sup>4</sup> Field Application and Research Development of the Abbreviated Injury Scale. Society of Automotive Engineers, 1968.

Of the 432 data items in the translation, 5 were considered "not possible" (NP); in 26 cases Dr. States upgraded the AIS values which were assigned by the Traffic Records Project; in 5 cases he gave lower values to the injuries; and there were 3 instances in which the translation was too vague to be reliable. Initially, we found the coding scheme to be 91 percent compatible with the AIS, (393 of 432). After Dr. States' adjustments had been made in upgrading and/or lowering the values assigned, it was then translatable in over 98 percent of the cases (424 of 432). In only slightly more than 3 percent of the cases (13 of 432) did we find that the 13 comparisons were either too vague or impossible to rely upon. Details of this translation may be obtained on request from the Technical Reference Branch, NHTSA, Washington, D.C. 20590.

## CONCLUSION

It has long been recognized that there is a need for more accurate data about motor vehicle injuries at the earliest possible interval after the accident occurs. Previous attempts at communicating these injuries were either vague or highly judgmental. We believe that the New York State Injury Coding Scheme approach to the problem serves all areas of accident investigation. It is more precise than the National Standard and the New York State Classification of K-A-B-C and, therefore, provides uniformity throughout all police agencies Statewide.

It is the opinion of the Traffic Records Project and the New York State Department of Health that this code is viable. With more emphasis being placed on emergency medical care by ambulance personnel, with better trained first responders at the scene of an accident and with better communication between the accident scene and the hospital, we are confident that this code will play an important role in saving lives on New York State highways.



A-1  
**APPENDIX A**

Police Agency \_\_\_\_\_

Test of Alternative Injury Code \_\_\_\_\_

Date of Accident \_\_\_\_\_

Confidential Report

Directions: This report form is to be filled out for every person injured or killed in a traffic accident. Circle first the location of the most severe physical complaint in Column 1 and then circle the type of Physical complaint in Column 2 pertaining to the anatomy. Also indicate victims status by checking appropriate item in Column 3. Code only what is observed at the scene — no hospital follow-up is necessary. Definitions of types of physical complaint and victims status are on reverse side of form.

Location of Physical Complaint Column 1	Type of Physical Complaint Column 2	Victim Status Column 3
A. Head	1. Amputation	<input type="checkbox"/> Apparent Death
B. Face	2. Concussion	<input type="checkbox"/> Unconscious
C. Eye	3. Internal	<input type="checkbox"/> Semiconscious
D. Neck	4. Minor Bleeding	<input type="checkbox"/> Incoherent
E. Chest	5. Severe Bleeding	<input type="checkbox"/> Shock
F. Back	6. Minor Burn	<input type="checkbox"/> Normal
G. Shoulder-upper arm	7. Moderate Burn	
H. Elbow-lower arm-hand	8. Severe Burn	
I. Hip-upper leg	9. Fracture - Dislocation	
J. Knee-lower leg-foot	10. Contusion - Bruise	
K. Abdomen	11. Abrasion	
L. Victim (Over all status)	12. Complaint of Pain	
	13. None	

Victim:	Ambulance Used	Yes No
<div style="display: flex; justify-content: space-between;"> <span>Last _____</span> <span>First _____</span> <span>M.I. _____</span> </div> <div>Address _____</div>	<div style="border: 1px solid black; height: 25px; margin-bottom: 5px;"></div> <div>Name of Ambulance</div>	<div style="border: 1px solid black; height: 25px; margin-bottom: 5px;"></div> <div>Hospital Taken To</div>
<div style="display: flex; justify-content: space-between;"> <span>City _____</span> <span>State _____</span> <span>ZIP Code _____</span> </div> <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <span><u>Age</u></span> <span><u>Sex</u></span> </div>	<div>Time Ambulance Arrived at Location</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="border: 1px solid black; width: 100px; height: 30px;"></div> <div style="text-align: center;">A.M. P.M.</div> </div>	<div>Time Ambulance Departed Location</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="border: 1px solid black; width: 100px; height: 30px;"></div> <div style="text-align: center;">A.M. P.M.</div> </div>
<div>Drivers Name if not Victim:</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <span>Last _____</span> <span>First _____</span> <span>M.I. _____</span> </div>		

Officers Comments:

Instructions for Officer's Comments

- (1) If injury cannot be coded, describe in writing.
- (2) If two severe injuries are sustained by the victim

Column 2

1. Amputation - Severed parts.
2. Concussion - Dazed Condition as a result of blow to head.
3. Internal - No visible injury but signs of anxiety, internal pain, thirst.
4. Minor Bleeding - Slight discharge of blood.
5. Severe Bleeding - Steady flow of blood that is not controlled.
6. Minor Burn - Reddening of the skin.
7. Moderate Burn - Reddening, blistering of skin over large area.
8. Severe Burn - Reddening, blistering or charring of the skin over a large portion of the body.
9. Fracture - Dislocation. Evidence of displacement of bones.
10. Bruise - Discoloration.
11. Abrasion - Top layer of skin is scraped.
12. Complaint of pain.
13. None - No visible injuries but Victim is other than normal.

Abnormal behavior should be stated in officers comments i.e., (Mental illness, Drug use, impairment similar to that produced by alcohol).

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Definitions of  
Victims Status

Column 3

1. Apparent Death
2. Unconscious - Victim unaware of his surroundings, does not respond to stimuli (verbal or physical).
3. Incoherent - Lacking orderly continuity of thought.
4. Shock - Depressed condition of all body functions, resulting from serious injury or incident.
5. Normal - Conscious and aware of surroundings.